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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Central 1885. *Telegrams: CIRA*

The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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The F.B.I. and Tariff Policy

The Federation of British Industries is putting forward to His Majesty's Government three definite recommendations designed to make the competing power of the British manufacturer more powerful by what the Federation believes to be a more equitable tariff policy. These recommendations are: (1) That in order to maintain the protection of the home market against dangerous competition in the future it should be the declared policy of His Majesty's Government to impose quotas on foreign manufactured goods where necessary and that power should be taken to enable this to be done. (2) That in the case of the export trade (*a*) action should be taken by the Government whenever necessary, under the powers already possessed by them, to retaliate against countries which discriminate against United Kingdom goods, or impose restrictions upon the payment for such goods; (*b*) benefits of the Most Favoured Nation treatment should be confined to countries which are prepared to make an agreement providing for satisfactory treatment of United Kingdom goods and a higher rate of duties should automatically be applicable to countries with which it proves impossible to arrive at such an agreement. (3) That in foreign negotiations care should be taken to ensure that in assessing the balance between Great Britain and any foreign country the main criterion should be the balance of domestic produce and manufactures, which are more important to national economy than re-exports. Foundry owners will have little to quarrel with these suggestions but they may take umbrage at certain proposals made in connection with inter-imperial trade.

The Federation is of opinion that the United Kingdom is not getting its rightful share of this important section, as a departure has been made from the basic principle "that protective duties shall not exceed such a level as will give United Kingdom producers full opportunity of reasonable competition." No one can take exception to that, but a further suggestion is that there should be a measure of protection against the duty free importation of Dominion manufactured goods on the grounds of the low level of wage costs in certain parts of the Empire. What the Federation may have in mind as a manufactured article may be the raw material of the foundry industry. That at the moment this is recognised by the British producers is confirmed by their augmentation of supplies from foreign sources. In general the suggestions of the Federation will be welcomed, as their adoption by the Government would give increased elasticity in tariff legislation, a desirable factor in this unstable world. A fixed tariff policy does obviously carry certain advantages, but where other countries' policies are labile, their rapid reaction to them must be an essential counter point.

John Wilkinson

A contemporary has recently given some interesting details of the life of John Wilkinson, the famous inventor or improver of the cupola, which add to the information given for instance in Mr. Hurst's book on cupola melting. Just outside Wrexham is the village of Bersham near which the old blast furnace stood, fed first with charcoal and later with coal, and where the old forge was. Green fields still bear names given in those days, such as Smelting-House Field, Rolling-Mill Meadow. Iron was smelted at Bersham in the seventeenth century, but it was in the eighteenth when a Cumberland farmer, Isaac Wilkinson, bought the furnace and brought his sons John and William to work it. John had been educated at the private school at Nantwich kept by Dr. Joseph Priestley, who, indeed, married his sister Elizabeth Wilkinson. After the Priestley riots in Birmingham, where a statue to Priestley now stands, John Wilkinson provided for the family. The growth to fame of John Wilkinson, and his brother's visit to France to instal the cupola there, still called the "*four Wilkinson*," are well known, and William had become famous and powerful too. John saw the difficulties which James Watt and Matthew Boulton had over their steam-engine cylinders, and he cast a cylinder such as he cast for cannon, and bored it out to a much higher degree of accuracy. For some years all the Watt and Boulton cylinders were made at Bersham, where the Wilkinsons installed the first steam-engine made at Soho to augment their water power. John became the greatest English ironmaster, with various works, coal pits and lead and copper mines under his control, and in 1787 made the first iron ship. John began new works at Brymbo, nearer to the mines, and refused to allow William to participate in the enterprise, and a quarrel between the brothers led to the end of the Bersham foundry. They appear to have incited people to destroy each other's plant, and the foundry at Bersham was closed, most of the people concerned moving to Soho, where Watt's works was established. John became High Sheriff of Denbighshire in 1799 and died at

(*Continued on page* 496.)

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John Wilkinson

(*Continued from page* 495.)

the age of 80. He had arranged to be buried in an iron coffin in his old family home in Cumberland. Less than 150 years spans the period from the first iron ship to the "Queen Mary," and one moral to be drawn is that the tide of change is irresistible, and for individuals to try and resist it is foolish and futile. Since the pace accelerates, not only in science and industry but in social and political affairs, no man to-day can rest in the assurance that anything will "last his time."

CONFERENCE SNAPSHOTS

Top.—THE EDITOR holds the fort. *Below.*—MR. BROWN, DR. JUNGBLUTH and a friend aboard the "Marchioness of Graham."

Below.—MR. FRANK HUDSON (Oliver Stubbs' medallist) with MRS. J. E. HURST. *Bottom.*—MR. V. DELPORT, MR. V. STOBIE and MR. D. H. WOOD manage to catch the train.

The Second Edward Williams Lecture

Cast Iron and the Engineer

By Professor A. L. MELLANBY, D.Sc., M.I.Mech.E. (Royal Technical College, Glasgow)

The lecturer's first introduction to the members of the Institute of British Foundrymen arose from an investigation with which he was charged, dealing with the qualities of cast iron suitable for Diesel engines. It occurred to him that some account of these early researches might be of interest, and that by recalling past experiments and investigations, which have now been largely forgotten, listeners might be able to form some mental picture of the difficulties which lay in the path of those British engineers who first took up the manufacture of large marine Diesel engines. It also appeared that, in view of the interest shown by Mr. Williams in the metallurgy of bygone days, these historical reminiscences might not be out of place in a lecture offered as a tribute of general admiration for so popular a member of the Institute.

It was in June, 1917, that a small deputation from the British Marine Oil Engine Manufacturers' Association called at the College and discussed with the then Director, Dr. Stockdale, and the lecturer the possibility of carrying out a programme of research upon cast iron in the College laboratories. It was finally arranged that the work would be under the lecturer's general supervision and that in the first instance there should be made (1) a collection of available trustworthy data upon cast iron and (2) an examination, analysis and testing of specimens which, with their history, would be furnished by members of the Association.

Previous Work

Growth of Cast Iron.—The lecturer would have hesitated to undertake this work but for the fact that he had been promised the co-operation of his colleague Prof. Campion, whose name and work must be known to all foundrymen. Whatever success attended this investigation was largely due to him, and it is pleasing to have this opportunity of acknowledging the wholehearted manner in which he carried out his share of the programme.

It was recognised that difficulties were likely to arise with the cast iron used for Diesel-engine cylinders and pistons from its growth after repeated heatings and coolings, and it may be of interest to learn of the information relating to this phenomenon that was then available.

Although the possibility of growth had been noted and communicated to the Royal Society by Beddoes in 1791, it was not brought before the general engineering public until 1904. In that year, A. E. Outerbridge, Junior, read a Paper upon "The Mobility of Molecules of Cast Iron" before the American Institution of Mining Engineers. There he showed that a square cast iron test bar 1 in. by 1 in. section and 14⅛ ins. long, after being heated to 800 deg. C. and cooled to atmospheric temperature 27 times, increased both in sectional area and length until it assumed dimensions of 1½ in. by 1½ ins. in section and a length of 16½ ins.

Further investigations were made by Carpenter and Rugan, who presented their results in a Paper read before the Iron and Steel Institute in 1909. They confirmed the observations of Outerbridge by taking a bar of grey cast iron and heating it 99 times to temperatures varying from 850 to 950 deg. C. After the heatings, the bar had increased 37 per cent. in volume. For further investigation of the effect of the composition of the iron upon its growth they prepared a series of test bars of cast iron free from graphite with proportions of carbon varying from 4.03 per cent. to 0.15 per cent. Their results show that the bar with 4.03 per cent. carbon after heating 90 times to an average temperature of 900 deg. C. increased in volume by 6.9 per cent. and the bar with 0.15 per cent. carbon after 39 heatings to the same temperature had a very slight diminution of volume.

A further series of tests with bars of approximately constant total carbon content but with proportions of silicon ranging from 1 to 6 per cent. showed that the growth was roughly proportionate to the silicon content.

In another Paper presented by Carpenter to the Iron and Steel Institute in 1911, the effect of heating upon bars with an approximately constant carbon content of 2.4 per cent., but with manganese varying from 0.51 per cent. to 1.6 per cent., showed that, with the 0.51 per cent. manganese bar, 152 heatings produced an increase in volume of 7.49 per cent.; with 0.935 per cent. manganese, 151 heatings produced an increase in volume of 3.1 per cent., and with 1.6 per cent. manganese, 151 heatings resulted in no change of volume.

In the discussion of the Paper by Carpenter and Rugan results were given by Stead of experiments he had made for the purpose of determining the manner in which the growth of cast iron takes place, and he described the effect of heating, between 600 and 800 deg. C., for about 10,000 hrs., a plate of grey cast iron. In this case the specific gravity of the metal fell from 7.09 to 6.14.

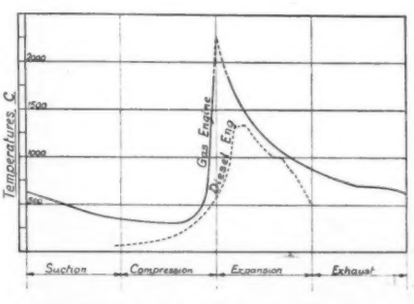


FIG. 1.—TEMPERATURE CURVES RELATING THE PERFORMANCES OF GAS AND DIESEL ENGINES.

It will be noted that Carpenter and Rugan and Stead dealt only with the effects of temperatures above 600 deg. C., but it was well known to steam engineers that growth occurred at much lower temperatures. In a Paper given to the American Society of Mechanical Engineers by I. A. Hollis in 1909, some experiences with superheated steam at about 500 deg. Fah. were given from which it was found (1) that fittings exposed separately to superheated steam at temperatures of about 500 deg. Fah. showed permanent increase in dimensions and (2) tensile tests from fittings which failed in service after such treatment indicated a permanent loss of strength.

There were also the experiments of Meyer, Cary, Longmuir and Hatfield to show that the high-temperature annealing of cast iron resulted in the appreciable diminution of both bending and tensile strength.

Working Temperatures in Cylinders of Internal-Combustion Engines

It was clear from these records that, before investigating more closely the properties of cast irons, some information was required about the actual temperatures to which the metal would be subjected under working conditions. At that time published figures dealing with the temperatures in Diesel engine cylinders were not known, but there were records from gas engines which it was hoped would give some guidance. Personal experiments upon a gas engine fitted with thermometer pockets in the cylinder liner showed that the highest temperature of the metal did not exceed 120 deg. C.

Information on this point was also found in a Paper by Hopkinson on "Heat Flow and Temperature Distribution in the Gas Engine," published in the Proceedings of the Institution of Civil Engineers. Here it is recorded that the highest temperature of the water-cooled parts, with boiling jacket water, was 200 deg. C. The maximum observed temperature of the piston (air cooled) was 480 deg. C., but under normal working conditions it was only 340 deg. C.

In another Paper by Coker and Scoble on the "Cyclical Changes of Temperature in a Gas Engine Cylinder," published also in the Proceedings of the Institution of Civil Engineers, the temperature fluctuations as well as the mean temperatures were recorded. The highest temperature at the end of the barrel was 109 deg. C. and the temperature fluctuation of the metal surface was not more than 10 deg. C. The maximum temperature of the piston was 340 deg. C. with a range of 80 deg. C. Under normal conditions the explosion temperature of the gas was between 1,830 and 1,950 deg. C., but under exceptional conditions it rose to 2,250 deg. C.

Diesel- and Gas-Engine Temperatures

These results indicated that, with an ample supply of water to the jackets, the liner temperature should never become very high, and it did not appear impossible to obtain a suitable mixture of cast iron, with good machining qualities, that would give satisfactory service.

The question naturally arose whether the average temperature of the gases during a cycle was higher in the gas engine than in the Diesel engine. Some information on this point may be obtained from Fig. 1, which shows, on a base of crank angles, the gas temperatures during a working cycle for each of these types of engine. The gas engine diagram is taken from the Paper by Coker and Scoble, and the temperatures in this example were, for the greater part, actually measured. The temperatures for the Diesel cycle were taken from the experimental engine in the Royal Technical College, but these were estimated from the indicator cards. The Diesel engine was working at about the full-rated load with a mean effective pressure of 92.4 lbs. per sq. in. The gas engine was working at its maximum load and the explosion pressure and temperature developed were much above the average.

In the absence of actually measured wall temperatures in the Diesel engine, it seemed reasonable to conclude that the liner temperatures would be lower than the gas engine temperatures already quoted. It was not so certain, however, that the piston temperatures in the Diesel engine would be lower than those in the gas engine. Although the maximum temperature of the combustion products of the Diesel engine is the lower, it seemed possible that the burning oil and air impinging directly upon the piston might be particularly effective in raising its temperature.

Wear of Cylinder Liners

For information upon the wear of cylinder liners industry was largely indebted to a Paper by Hurst, entitled "Cast Iron: With Special Reference to Engine Cylinders." This Paper was presented to the Manchester Association of Engineers, 1916. The author indicated that examination of the worn surfaces of gas engine liners discloses the fact that the whole surface is covered with small pits. Although these pits are often considered to be the holes from which the coarse plates of free graphite have been detached, he states that microscopical examina-

tion shows that the holes are the result of detachment of whole grains of any of the constituents. Attention was also drawn to the fact that the harder constituents are invariably found to be standing in relief, and in a micro-photograph the hard phosphide eutectic is to be seen.

He also considered the phenomenon of surface flow and discussed the formation of the layer of

FIG. 2.—MICROGRAPH OF BADLY-WORN CYLINDER LINER. × 110. UNETCHED.

hard material found on the surface of a gas engine cylinder liner after a seizure. Some attention was given to the Brinell hardness test which the author considered to be of very little use as an indication of the wearing properties of cast iron. He suggested that an iron with the highest inter-crystalline cohesion, otherwise the highest tensile strength, will possess the greatest resistance to surface disintegration and consequently to wear.

Hurst also dealt with the effect of machining on the resulting liner surface and stated that it was fortunate that the accuracy necessary in cylinder and liner dimensions required very careful machining. The question of growth of cast iron was also treated and, in discussing an example of a cracked Diesel piston top, he stated that the cracking was mainly due to the high phosphorus content. The author concluded by recommending the employment of low percentage silicon, the elimination so far as possible of the phosphorus, and the introduction of chromium. In view of the many loose statements prevalent at the present time upon wear in automobile engine cylinders, the careful study of this Paper, although published 20 years ago, is seriously recommended.

Further information upon cylinder-liner wear and piston seizure was also found in an article contributed to the "Petroleum World" by Smith and Primrose. These writers considered that the wear in a cylinder of which they gave particulars was due to the formation of an abrasive substance between the piston ring and the liner. They attributed the abrasive substance to the oxidation and growth of the cast iron of the piston rings under the high working temperature.

Examination of Samples Taken from Engines in Service

This section deals with the examination of a few of the samples sent for examination by different members of the British Marine Oil Engine Manufacturers' Association. The majority of these samples were taken from engines which had not proved altogether satisfactory in service, and it was hoped that examination would reveal the reasons for the troubles that had been encountered and that recommendation might be possible for the improvement of later castings.

The first sample to be considered was one taken from a cylinder liner which had worn badly in practice. The sample was not sufficiently large to provide tensile specimens, but a Brinell test gave a hardness number of 170.

The micrograph given in Fig. 2 shows how the large flakes of graphite cut up the material and how the phosphide eutectic is in excessive amount and badly segregated. The structure is obviously indicative of a material with a low resistance to abrasion.

The second sample was from a liner prepared from a mixture said to be specially recommended for internal-combustion engines. Tests showed it to have a tensile strength of about 12 tons per sq. in. and a Brinell hardness of 170. The micrograph (Fig. 3) shows graphite flakes of medium size but rather continuous in parts in a matrix of pearlite and a little free cementite. To be specially noted are the large and isolated patches of phosphide eutectic. The phosphorus percentage was 1.34, and the claim for its suitability for internal-combustion engines could scarcely be upheld.

The third example was taken from an engine liner which had cracked after running for about 100 hrs. It had a Brinell hardness number of 176 and a phosphorus content amounting to 1.07 per cent. The micrograph, Fig. 4, shows graphite in medium sized flakes in a pearlite matrix. The phosphide eutectic is present in excessive quantity in large and isolated patches.

The examples quoted are only a small section of those sent in for examination, but they may be taken as fairly representative of the cast irons that were at that time being used in marine Diesel engine practice. In the lecturer's report it was pointed out that the phosphorus content did not appear to have received from the engineer or the founder the attention it deserved, as, in the majority of samples submitted, the

FIG. 3.—POOR-QUALITY CYLINDER LINER METAL. × 110. ETCHED.

phosphorus content generally exceeded 1 per cent. The examination showed beyond doubt that the amount, manner of existence, and distribution of the phosphorus or its compounds had a very important influence upon the strength, wearing and growing properties of the iron.

Generally speaking it might be claimed that the examination of the specimens showed that (1) there was no recognised standard of composition or strength and (2) the failures described had been due, largely if not entirely, to the use of unsuitable metal containing too much and badly distributed graphite and phosphorus. In one or two cases, where iron of a fairly suitable composition had been used, want of control in the founding rendered it unsuitable for Diesel engine purposes. The fact that permanency of

FIG. 4.—CRACKED-LINER METAL AFTER 100 HOURS' WORK. × 110. ETCHED.

size and form and the retention of strength at high temperatures depended largely upon the stability of the carbides did not appear to be recognised so fully as was desirable.

Programme of New Work

As a result of the experience gained by the examinations first described, it was suggested that experiments be carried out upon an iron of approximately the following composition:—

T.C	...	...	3 per cent.
C.C	...	...	0.6 to 0.7 per cent.
Si	...	...	1.5 per cent.
Mn	...	...	1.0 to 1.5 per cent.
S	...	...	0.08 per cent. max.
P	...	...	0.50 per cent. max.

Some difficulty was experienced at first in finding a foundry willing to work to specification and with sufficient interest in the experiments to ensure that instructions would be properly followed. At that time the writer was introduced to the late Mr. Mayer—a Past-President of the Institute—of Hardie & Gordon, Dumbarton, who undertook to do the casting work and give all the personal assistance that was possible. It would have been difficult to find anyone better suited for the supervision of the foundry work or one who showed greater interest in the investigation. The help and advice he gave are here gratefully acknowledged.

In the early stages of this investigation, test pieces only, of metal made to the above specification, were used, and these were examined very completely in the laboratory. The properties to which it appeared necessary to devote the most attention were those of (1) strength at high temperatures; (2) growth after repeated heatings and coolings and (3) resistance to wear.

The first experiments were made to determine the tensile strength of the specimens at different temperatures. For this purpose the bars were placed in an electric furnace, mounted in the testing machines, and raised to the required temperature. Loading did not commence until the specimen had been subjected to the desired temperature for about 1 hr. 20 min. These tests

showed that the tensile strength diminished as the temperature rose, until at some point between 390 and 480 deg. Fah. it had its minimum value. With further increase of temperature the tensile strength rose until at about 750 deg. Fah. its value was higher than that at atmospheric temperature. This indication of a minimum strength at an intermediate temperature was quite unexpected and it was decided to investigate this point more closely in future experimental work.

In all published work upon growth of cast iron after repeated heating and cooling, the results had been confined to those cases where the temperature had been raised to about 1,600 deg. Fah. (870 deg. C.). It was felt, however, that the changes might be quite different for a lower range of temperature and a maximum of 900 deg. Fah. was selected for these tests. A large number of small specimens, ¾ in. diameter and 2 in. long, was prepared, and each piece carefully measured before placing it in the furnace. As a general rule the heating was started at about 9 a.m. and the current remained on until 6 p.m. At this time it was cut off, and the samples remained all night in the furnace so that they would have cooled down and be ready for measurement the next morning. The measured changes after 40 heatings and coolings were so slight as to be negligible, and it appeared that under such conditions cast iron of the composition given above was not liable to growth. So far as external appearance was concerned, no appreciable change appeared to have taken place in the metal.

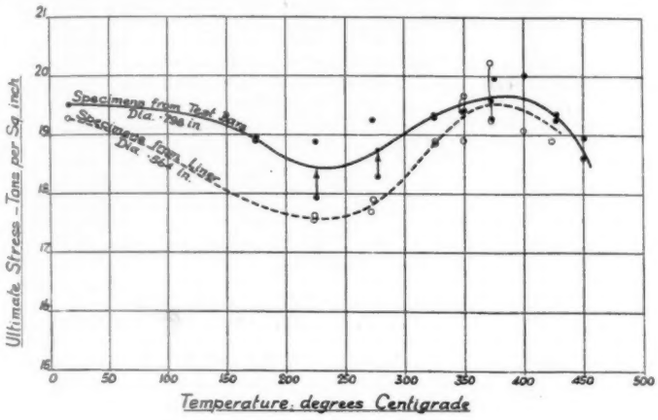


FIG. 5.—STRENGTH OF TEST BARS AND LINER MATERIAL AT HIGH TEMPERATURE.

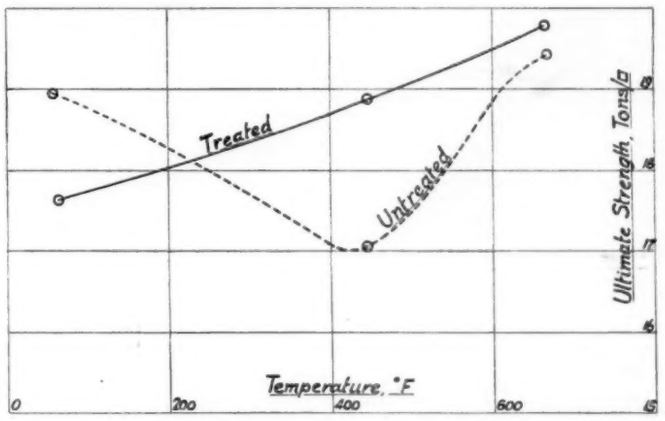


FIG. 6.—RELATIVE STRENGTH OF IRONS AFTER SOAKING AT 750 DEG. FAH.

Experiments with Liner Castings

From the experimental work just detailed it was considered that work was proceeding on the right lines and that an iron had been produced with a reasonable tensile strength at atmospheric temperature, and one that did not fall off to any appreciable extent in strength when the temperature was raised to values supposed to occur in Diesel engine practice. The resistance to growth was also satisfactory and microscopical examination showed that the repeated heating and cooling had no ill effect upon the structure.

It was therefore felt that castings of an actual liner might be made and that the effect of size and, in consequence, the rate of cooling of the casting, might be noted. Especially was it desired to know whether the good properties that appeared to be possessed by test specimens could be reproduced in castings of larger size. To determine this point a small liner of normal proportions was cast along with a number of both attached and separate test bars. Very detailed investigations were made upon the various samples thus provided, and some idea of the relative strengths at high temperatures of the test bars and of the liner may be obtained from Fig. 5. Here will also be noticed that minimum strength is associated with a temperature of about 250 deg. C. (480 deg. Fah.) and the unexpected rise of strength with temperature until a maximum is attained at 400 deg. C. (750 deg. Fah.). It will also be seen that, even from samples cut from the liner, a tensile strength of over 19 tons per sq. in. was obtained.

At this stage it was considered that the cast iron composition recommended had every appearance of being likely to prove satisfactory for Diesel engine liners and pistons. In order to give it a more thorough trial it was decided to cast a liner and piston that might be used in the College engine and to test them under running conditions as severe as possible. At the same time sufficient test bars were to be cast so that the phenomena of growth, strength at high temperatures and resistance to wear might be investigated in the more complete fashion to which the previous experience had shown the way.

The work was again entrusted to Messrs. Hardie & Gordon, who worked up the metal to the required composition in an air furnace, from which it was cast into small pigs ready for recharging. It had been intended to make the castings from an air furnace remelt of this material, but at the time the moulds were completed the furnace was out of action and the parts were, therefore, cast from a cupola melt.

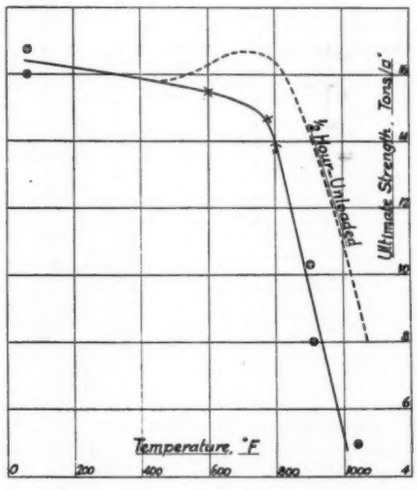


FIG. 7.—INFLUENCE OF PROLONGED SOAKING ON STRENGTH OF LOADED BARS.

As mentioned previously, the early experiments had shown that cast iron had a minimum tensile strength value at 450 deg. Fah. and a maximum at about 750 deg. Fah., the strength at the latter temperature actually exceeding that at normal temperature. It was proposed by Dr. Andrew, who had succeeded Prof. Campion in the Chair of Metallurgy, that a soaking of the material at a temperature associated with the maximum strength might favourably alter the strength at other temperatures. Tests were made to investigate this point and the results are shown in Fig. 6. The full-line curve marked "treated" shows that the effect of the heat treatment has been to increase the strength at all useful temperatures; in addition, the minimum strength characteristic at 450 deg. Fah. has entirely disappeared.

Ageing Effect

In the tests already described, the temperature at which the specimen was broken had been maintained for only about half an hour before pulling. It was felt that a longer heating period was desirable, and a series of tests was therefore instituted where the specimen was maintained for 24 hrs. at the selected temperature. These tests showed that, at a temperature of about 800 deg. Fah., a very serious reduction of strength followed from the longer period of heating. It appeared that this change in characteristics could only be accounted for by some ageing influence which had not time to make itself prominent in the half-hour period tests.

It seemed probable that any ageing effect which had a prominent influence on the strength of the material could only arise from a change in the crystal structure. Such change might be influenced by the stress on the material during the heating process; further, it appeared probable that an increase in the duration of the heating beyond the 24 hrs. might well lead to lower strength values. For these reasons it became necessary to consider tests involving very long heating periods, while in addition the material would be held under stress during the whole of the test. A special machine was therefore designed and constructed where the load was applied through a large coil spring which could be strained through a hand wheel and screw. The results are shown by the full line in Fig. 7, where, in some cases, the heating period extended to 115 hrs. The dotted curve represents the strength of the material with the heating period restricted to half an hour. The marked differences between the two curves show that tests of the half-hour heating periods are very misleading and serve no useful purpose. It is interesting to note the resemblance between those curves for cast iron and those now so commonly presented for steel specimens tested for the determination of the "creep" stress limit.

Wear Tests

Reference has been made previously to the tests for wear, and it may be interesting to describe the machine used for this purpose. A general view of the apparatus is shown in

Fig. 8, from which it will be seen that the specimen under test is attached to a balanced lever and is rubbed by the rim of a rotating wheel situated below. A definite weight, fastened to the lever, gives any desired pressure between the two rubbing surfaces. It was hoped that this apparatus might be arranged to give simultaneous indications of the wearing properties of cylinder-liner samples and of piston rings. For this purpose the wheel was arranged to take different rims and several castings of piston ring quality were obtained for this purpose. This hope was not realised, as it was found that however much the fixed sample was worn away, the diameter of the revolving wheel remained constant. Some difficulty was experienced at first in obtaining consistent results until it was noted that the moisture content of the atmosphere had a disturbing effect. By transferring the machine to a heated room all difficulties were removed. A comparison of the results of wear tests made from the new liner and the one it replaced is shown in Fig. 9. The superiority of the new material is at once evident.

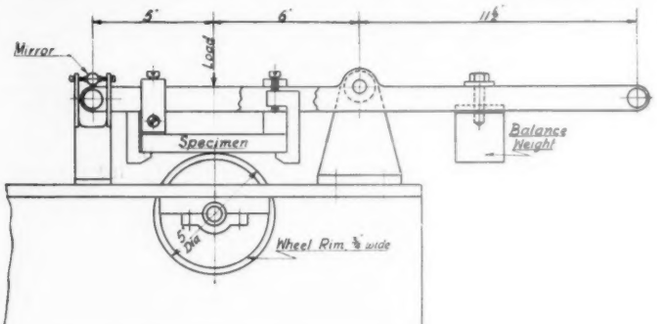


FIG. 8.—MACHINE FOR DETERMINING THE WEAR-RESISTING PROPERTIES OF IRON.

Growth Tests

For this investigation it was first necessary to fix upon a soaking temperature which would be representative of oil-engine conditions. As will be seen later, experiments on the College engine showed that a temperature of 970 deg. Fah. (521 deg. C.) covers all normal running loads. In large engines with water-cooled pistons this temperature is well above the highest attained by the piston in any but exceptional circumstances.

In the early experiments specimens 2 in. long and ¾ in. dia. were used, but experience showed that it would be better to increase the length of the specimen to 6 in. and to determine the change of length in a measuring machine. The daily heating of the specimen occupied 6 hrs., overnight it cooled in the furnace and in the morning it was brought to standard temperature by placing it for an hour in the case containing the measuring machine. The results from repeated heatings of the new liner sample are shown in Fig. 10, and it will be accepted that the figures shown are very satisfactory. There are also shown the readings taken from a sample cut from the lower end of the old liner. The use of a trunk piston on this engine makes it unlikely that the specimen was subjected to more than a very moderate temperature during its working life, and it may be taken as representative of the material in the condition in which it left the foundry. In the early heatings this material grew rapidly, but after the fifth heating it suddenly changed to a much more moderate rate of growth.

From this brief outline, it will, it is hoped, be accepted that the lecturer and his colleagues had to a large extent accomplished one object of the research. A liner and piston had been produced, the material of which maintained its strength at all temperatures likely to be reached in oil-engine practice, it showed excellent wearing qualities and its growth was negligible. The liner and piston have now been working in the College engine for over 15 years, and during part of that period they have been running under conditions much more severe than any that occur in normal practice. No trouble has been experienced and when last measured the liner wear was negligible.

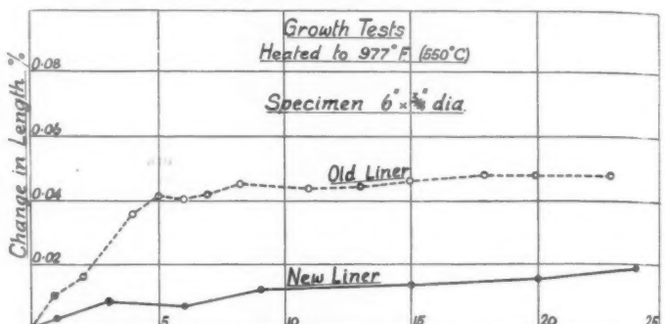


FIG. 10.—GROWTH-TEST RESULTS ON OLD AND NEW LINERS.

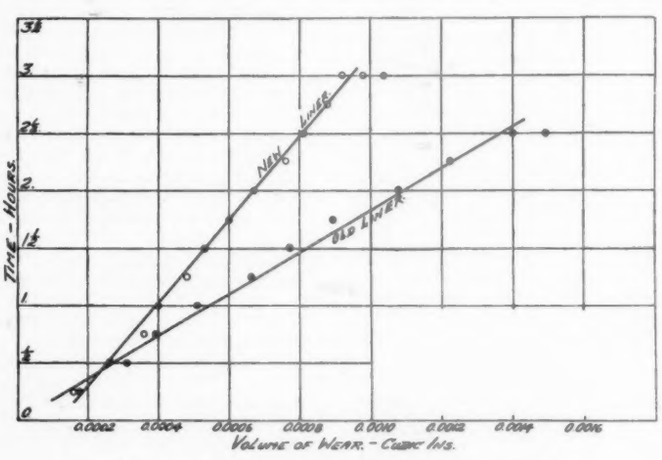


FIG. 9.—COMPARATIVE RESULTS OBTAINED FROM WEAR-TESTING OLD AND NEW LINERS.

Diesel Engine Temperatures

This lecture has been devoted chiefly to the problems associated with the qualities of cast iron required for oil-engine pistons and cylinders. Reference, however, has been made to temperature effect, and it may therefore interest members to learn what are the actual temperatures to which the piston is subjected during its working cycle. The curves shown in Fig. 11 illustrate how the piston temperature varies from centre to circumference with different loads. The curves also show the influence of the outlet temperature of the jacket water. The temperatures given are those at the lower surface of the piston and from further experimental work upon the temperature gradient through the metal, it is estimated that the maximum piston temperature at full load (100 lbs. sq. in. m.e.p.) would be about 850 deg. Fah. At an overload represented by a mean effective pressure of 125 lbs. per sq. in. the temperature would be increased to about 950 deg. Fah.

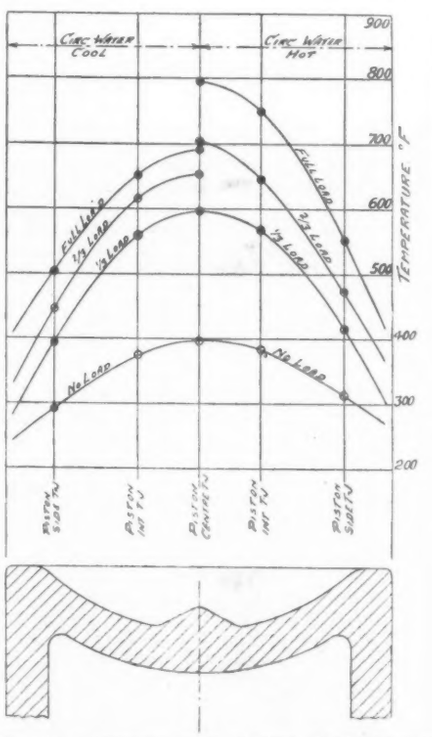


FIG. 11.—SHOWING HOW PISTON TEMPERATURES VARY FROM CENTRE TO CIRCUMFERENCE WITH DIFFERENT LOADS.

The lecturer already has referred to the assistance given in this work by Prof. Campion. He must also gratefully acknowledge the advice and help of Prof. Desch and Prof. Andrew, both of whom held the position of Professor of Metallurgy while the work was proceeding. Especially has he to be thankful for the assistance of Dr. John S. Brown, who devoted himself so wholeheartedly to the mechanical part of the research programme.

The account of this early work is now at an end, and it is hoped that it has awakened some interest in the difficulties that had to be overcome by the manufacturers of the early marine oil engines. To the younger generation it may appear ridiculous that there should have been any real problem and they may wonder why so much experimental work was necessary before liner and piston cracking changed from common occurrences to far-away memories.

But it is thought that with the arrival of any other new set of engineering conditions, problems of a type similar to those which were encountered will again arise, and experimental research will still be necessary for their solution. At the present time there is available for assistance in the foundryman's day-to-day difficulties, the staff and equipment of the British Cast Iron Research Association.

It is gratifying that the membership of the Association is so large and that so much advantage is taken of the facilities it offers. To the lecturer the study of the annual reports is one of ever-increasing interest. When he learns of the tremendous advances that have taken place in recent years, largely due to the work of Mr. Pearce and his able staff, he feels proud that for a period he was privileged to work along with some of the members of the Institute in the same field.

THE DIRECTORS of Guest, Keen & Nettlefolds, Limited, report that the new wire-rod mill at Cardiff, which was completed during the last financial year, is running with satisfactory results. In furtherance of the works reorganisation policy, the directors have authorised the transfer to Cardiff of the wire-drawing and wire-nail plant, and their complete modernisation.

Institute of British Foundrymen

ELECTION OF NEW MEMBERS

At a Council Meeting of the Institute, held at Glasgow on June 9, 1936, the following were elected to the various grades of membership.

As Members.

A. Baillot, works manager, Foundry Equipment, Limited, Leighton Buzzard; A. E. Baillot, foundry demonstrator, Foundry Equipment, Limited, Leighton Buzzard; E. Baillot, foundry engineer, Foundry Equipment, Limited, Leighton Buzzard; J. A. Barbour, representative, Morgan Crucible Company, Limited, London; R. E. Berk, sales manager, District Chemical Company, Limited, London; E. C. Carrott, foundry staff, Ruston & Hornsby, Limited; A. G. Corrie, director, Foundry Equipment, Limited; J. B. Corrie, chairman, Foundry Equipment, Limited; W. McL. Dick, district manager, Stanton Ironworks Company, Limited, Glasgow; A. T. Gray, proprietor, Burkinshaw Coal Company, Glasgow; A. Fraser, engineer, A. Fraser & Company, Glasgow; T. H. Hawley, foundry manager; A. R. Parkes, metallurgist, Suffolk Iron Foundry (1920), Limited; W. B. Parkes, chemist, Austin Motor Company, Limited; G. Price, steel foundry estimator, E. Allen & Company, Limited; R. Scott, pig-iron salesman, Stanton Ironworks Company, Limited, Glasgow; J. Steven, brassfounder, Steven & Struthers, Glasgow; P. Wyatt, representative, Stanton Ironworks Company, Limited, London; A. H. Young, engineers representative, Sir W. G. Armstrong, Whitworth & Company, Limited, London.

As Associate Members.

N. M. Arthur, foundry engineer, Glenfield & Kennedy, Limited; J. Brooks, foundry foreman, J. Henry, Limited, Leeds; A. Codd, foundry foreman, Ruston & Hornsby, Limited; R. C. Elwell, foundry chargehand, Austin Motor Company, Limited; G. H. Gardner, cupola foreman, Stanton Ironworks Company, Limited; J. J. Hazlewood, foundry foreman, Hunt Bros. (Oldbury), Limited; T. R. Langley, steel foundry foreman, Babcock & Wilcox, Limited; E. F. Hodges, assistant metallurgist, Crane, Limited, Ipswich; C. G. Kimberley, patternmaker, Austin Motor Company, Limited; G. W. King, shop foreman, Nigerian Railway, West Africa; L. F. Parsons, loam moulder, General Electric Company, Limited, Witton; O. B. Pizzy, foundry foreman, Suffolk Iron Foundry (1920), Limited; T. Wolverson, metallurgist, Vowles Bros., Limited, West Bromwich; V. N. Wood, assistant metallurgist, Crane, Limited, Ipswich.

As Associate (Student).

J. W. Close, foundry student, Whitley Partners, Railway Works, Leeds.

Shipyard Work

Ellerman Lines, Limited, have placed orders for six high-speed cargo liners, as follow:—Two twin-screw turbine liners, each of 10,600 tons deadweight, to be built by Cammell Laird & Company, Limited, Birkenhead; two turbine cargo liners of 9,800 tons deadweight, to be built by Barclay, Curle & Company, Limited, Glasgow; and two cargo liners, of 4,300 tons deadweight, to be driven by reciprocating engines with Bauer Wach exhaust turbine, to be built by Wm. Gray & Company, Limited, West Hartlepool.

SNAPPED IN SCOTLAND

(1) MR. A. H. GUY, a visitor from South Africa. (2) MR. ROY STUBBS and a friend. (3) The NEW PRESIDENT relaxes. (4) MR. C. W. BIGG, the new Senior Vice-President. (5) MR. J. E. HURST finds time for photography. (6) MR. and MRS. J. G. PEARCE. (7) MR. J. H. COOPER. (8) MR. PAUL FASSOTTE and MR. CAMPBELL. (9) MR. O'KEEFE and MRS. GARDOM. (10) MR. A. SUTCLIFFE.

Composition and Its Effect upon the Properties of Mould and Core-Sand Mixtures at Elevated Temperatures

By F. HUDSON

(*Concluded from page 460.*)

Further to the effect of coal-dust and sawdust additions upon the properties of mould and core materials at elevated temperatures, other materials were tried with entirely negative results. For example, the addition of blacking or crushed coke had no effect on any of the properties at high temperatures. The presence of volatile matter in the addition appears to be essential for the results obtained in this Paper, and apart from those additions investigated the only others likely to act in a similar capacity are horse manure, pitch, oil and cereal binders, etc. The effect of blacking additions is indicated by mixture No 16 (see Table IV and Figs. 12, 13 and 14). At the present stage of this investigation the author cannot give any logical explanation as to the reason for the effect of volatile matter in the direction stated.

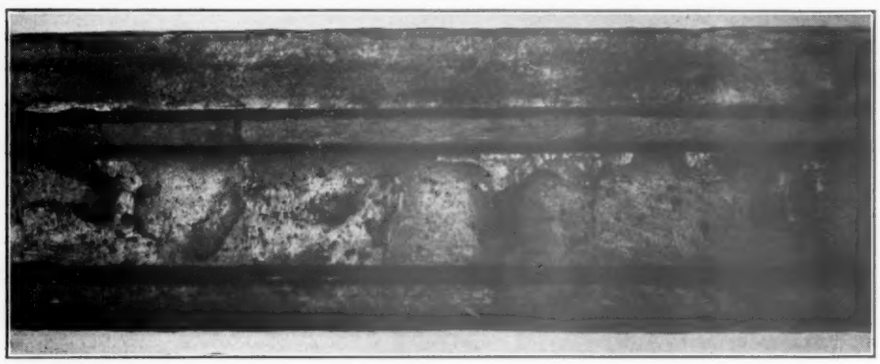


FIG. 9.—TYPICAL DEFECTS DUE TO SAND BUCKLES FROM CORE ON LONG GROOVE CASTING.

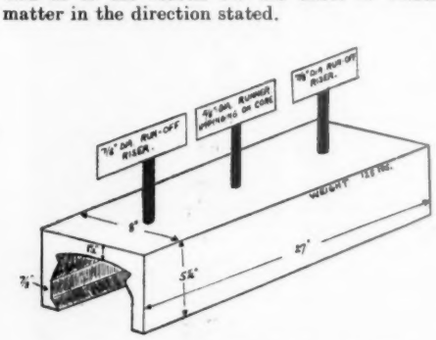


FIG. 10.—SECTIONAL DRAWING OF EXPERIMENTAL CASTING USED TO DETERMINE THE SUSCEPTIBILITY OF VARIOUS SAND MIXTURES TO PRODUCE BUCKLES.

The addition of sawdust to dry sand has long been a standard practice in many foundries, but its action has never been fully understood and it is hoped that the foregoing remarks may help to substantiate the value of this material as an addition to mould and coresand mixtures. There is no doubt whatsoever that as a preventive of buckles and surface scabs the use of sawdust is extremely beneficial. The author has contended for some time that these defects are essentially associated with the question of sand expansion, and a few remarks upon this question may be of interest. In the first case, from personal observation it has been noticed that these defects are most common when the following factors apply:—

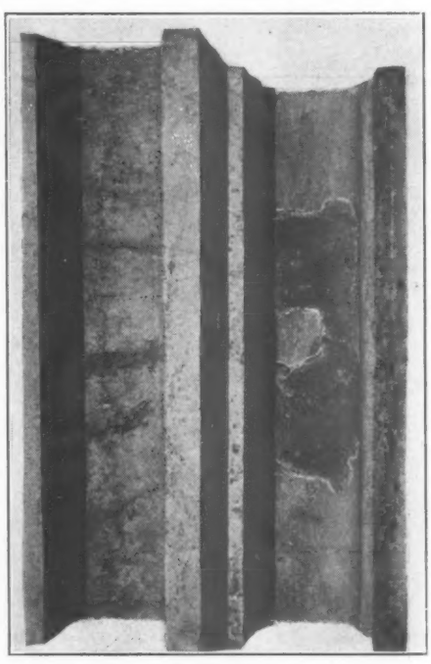
(1) *Impingement of metal upon a localised area of mould or core.*—In many instances, castings have to be made when the position of the runner is such as unavoidably to produce the above condition. The likelihood of defects being produced is aggravated when the area exposed to the action remains uncovered by the rising metal in the mould until a late stage in the pouring operation. Furthermore, the higher the casting temperature the greater the risk.

(2) *The design of the casting.*—If the factors as outlined above are associated with mould and core designs leading to a convex surface, the chance of producing sand buckles is still further increased. Large rectangular mould and core surfaces are also most susceptible. In the case of long narrow surfaces such as arise in the production of columns, etc., the defects may occur along the casting length as shown in Fig. 9, whilst on broader sections the defect might possibly occur at the corners, or at such points where opposing expansion stresses meet.

In order to prove that sand expansion has an important bearing upon the production of the defects under review, experimental castings were made as shown in Fig. 10, incorporating a dry-sand core having a convex surface. Furthermore, in order to ensure the worst possible conditions the runner was allowed to impinge upon the centre of the core's convex surface and the pouring temperature was kept as high as possible—between 1,350 and 1,400 deg. C. In each mould the sand used for making the core varied, and the extent of the defects produced noted and recorded as shown in Table III. Those sands having a high coefficient of expansion, and which increased in strength on heating, buckled under the runner in every case, although the physical properties at atmospheric temperature were perfectly safe for casting production. Fig. 11 illustrates a comparison between test castings, showing in one case the core badly buckled under the runner, against a sound casting obtained by the use of a core sand having suitable high-temperature characteristics.

Many practical men attribute the cause of such defects as these to lack of permeability, moulds improperly dried, etc., and it is interesting to compare sands A and B in Table III in connection with the effect of permeability. It will be observed that sand B has a permeability figure of 177, which is high for ironfoundry practice, yet it scabbed just as badly as sand A with a permeability number of 87. In regard to the other factors common to the production of moulds, it might be mentioned that in this series of tests there was no doubt whatsoever about all the cores being dry, and, in regard to the question of ramming, it was found that in those sands susceptible to scabbing various ramming densities did not remove the trouble.

It is also interesting to note the results obtained with sand C containing about 4½ per cent. coal dust. This sand probably scabbed due to not enough coal dust being present to give the requisite high-temperature characteristics required by the conditions of test, although when 7½ per cent. coal dust was added satisfactory results were obtained. It is contended that the cause of surface scabs or buckles is due to the combined effects of expansion and increase of sand strength on heating, and any factor reducing either property will tend to eliminate the trouble. Complete prevention will ultimately depend principally on the design of casting, its size, the position of the runners, pouring speed and the type of metal employed, and to ensure positive results the sand expansion must be reduced to an absolute minimum, whilst the compression strength at high temperatures must be the same or slightly lower than at atmospheric temperature. For steel-casting production the above statement is of particular importance, but some latitude can no doubt be allowed in the case of cast iron. In regard to oil sand H, although this sand has a fairly high degree of expansion, there is no increase of strength on heating, and consequently less chance of localised stresses being produced leading to fracture or buckling of the sand surface. On the other hand, there is a definite possibility of that portion of the oil-sand core underneath the runner being washed away by the metal, due to too rapid a strength decrease, and this must not be confused with



A B

FIG. 11.—ILLUSTRATING THE EFFECT OF USING A SAND HAVING SATISFACTORY PROPERTIES AT ELEVATED TEMPERATURES (A), AGAINST MATERIAL WHICH HAS UNSUITABLE HIGH-TEMPERATURE CHARACTERISTICS (B), FOR ELIMINATING SAND BUCKLES ON "DUMB SCABS."

the defects under review. In this particular case, the oil-sand mixture contained a considerable percentage of clay bond to minimise the decrease in strength consequent on heating and to prevent undue erosion by the metal stream.

TABLE III.—*Effect of Composition of Mould and Core-Sand Mixtures in Relation to the Formation of Defects*

Type of sand.	Mixture. (All milled 5-10 min.).	Physical properties at atmospheric temperature. App. den.	Per cent. moisture.	Compression strength. A.F.A. lbs. per sq. in. Green.	Compression strength. A.F.A. lbs. per sq. in. Dried.	Dried permeability. No. A.F.A.	Remarks.
A. Ord. dry sand	30 per cent. reclaimed oil-sand cores, 69.25 per cent. dry-sand floor sand, 0.75 per cent. bentonite	1.69	8.0	4.6	128.5	87.0	Core badly buckled under runner.
B. Ord. dry sand	96 per cent. sea sand, 4 per cent. bentonite	1.56	6.4	5.6	140.8	177.0	Core badly buckled under runner.
C. Ord. green sand	93.875 per cent. green-sand floor sand, 1.5 per cent. Scottish rotten rock, 4.5 per cent. coal dust, 0.125 per cent. liquid binder	1.53	7.3	4.5	52.8	96.0	Core badly buckled under runner.
D. Dry sand containing 7½ per cent. coal dust	30 per cent. reclaimed oil-sand cores, 61.75 per cent. dry-sand floor sand, 0.75 per cent. bentonite, 7.5 per cent. coal dust	1.60	9.9	5.3	134.4	58.0	Free from defects.
E. Dry sand containing 7½ per cent. sawdust	30 per cent. reclaimed oil-sand cores, 60.7 per cent. dry-sand floor sand, 1.8 per cent. bentonite, 7.5 per cent. sawdust	1.38	13.8	3.7	74.9	107.0	Free from defects.
F. Dry sand made from crushed old firebricks	97 per cent. crushed old firebricks, 3 per cent. bentonite	1.68	11.0	5.4	233.6	69.0	Free from defects.
G. Specially-developed sand for steelfounding (mix No. 19)	89 per cent. crushed old firebricks, balance special mixture of solid and liquid bond plus expansion reducer	1.55	18.4	4.0	141.8	97.0	Free from defects.
H. Oil sand	87 per cent. sea sand, 10 per cent. Scottish rotten rock, 3 per cent. semi-solid core binder	1.46	Trace	1.0	997.4	190.0	Free from defects.

Notes.—In tests A, B, C, and H, the core was protected with ordinary foundry blackwash containing clay water, blacking and a little core-gum, as outlined in Table VI.

In tests D, E, F, and G, the core was protected with blackwash made from 5 parts water, 1 part proprietary binder and enough blacking to form a thin cream, as outlined in Table VI.

APPERTAINING TO STEEL FOUNDING

The Paper up to this point has dealt mainly with sands commonly used for the production of iron castings, but before concluding it would be advisable to comment upon the position in the steelfoundry. In the previous Paper* published by the author some tests were conducted at elevated temperatures upon steelfoundry "compo," and the results obtained were far from satisfactory. Consequently an attempt has been made to produce a superior material, using crushed old firebricks as a base. This material was selected in view of its low initial expansion on heating, and also because it is fairly readily obtainable in most foundries. Various additions were made to this base and moulding compositions produced having properties at atmospheric temperature, shown in Table IV, whilst Figs. 12, 13 and 14 give some indication of the characteristics at elevated temperatures. The result of the research eventually produced mixtures Nos. 18 and 19, which the author considers have nearly ideal properties for casting production.

It will be observed that the effect of heat on mixture No. 18 results in practically no expansion, slight decrease in strength, and an extremely easy fettling operation. Mixtures Nos. 18 and 19 have been most thoroughly tested out in the ironfoundry under all conditions, with extremely satisfactory results, and at present mixture No. 18 is being tried out for steel-casting production. At the time of writing these tests are not completed, but no doubt some further information will be available when the Paper comes up for discussion. So far as one can see, however, mixture No. 18 should be particularly suited for the production of steel castings and superior to many of the moulding compositions at present in service. Table V summarises the main properties at elevated temperatures of the various mixtures covered by this Paper.

* "Some Properties of Mould and Core Materials at Elevated Temperatures," FOUNDRY TRADE JOURNAL, December, 5, 1935.

TABLE IV.—*Moulding Composition made from a Base of Crushed Old Firebricks.*

Mix. No.	Mixture composition.	App. den.	Per cent. moisture.	Compression strength. A.F.A. lbs. per sq. in. Green.	Compression strength. A.F.A. lbs. per sq. in. Dried.	Permeability. A.F.A. No. Green.	Permeability. A.F.A. No. Dried.	Per cent loss on ignition.
12.	96 per cent. crushed old firebricks, 4 per cent. bentonite	1.66	11.9	4.9	150.4	304	501	0.86
13.	95 per cent. crushed old firebricks, 4 per cent. bentonite, 1 per cent. coal dust ..	1.60	11.0	5.1	211.2	188	370	3.30
14.	As above, plus 5 per cent. coal dust ..	1.51	10.9	5.1	176.0	242	377	6.55
15.	As above, plus 7½ per cent. coal dust ..	1.51	11.2	5.9	214.4	197	313	8.15
16.	91 per cent. crushed old firebricks, 4 per cent. bentonite, 5 per cent. blacking ..	1.61	11.3	6.2	243.2	98	163	5.40
17.	91 per cent. crushed old firebricks, 3 per cent. bentonite, 6 per cent. tar	1.61	12.3	4.1	164.8	125	304	6.05
18.	90 per cent. crushed old firebricks, balance special mixture of solid and liquid bond plus expansion reducer	1.55	17.5	3.8	151.2	59	182	7.69
19.	89 per cent. crushed old firebricks, otherwise similar to above	1.55	18.4	4.0	141.8	30	97	8.96

Note.—The base of old dry crushed firebricks had the following preliminary treatment :—

Mixture 12.—All grades other than 20-30 mesh removed.

Mixture 19.—As crushed. No fines removed.

Remainder.—All fines passing 80 mesh removed.

The base material was then milled for 5 to 10 min. with additions.

APPERTAINING TO FOUNDING IN GENERAL

Permeability and Mould and Core Protective Coatings

No investigations have been conducted relative to the effect of elevated temperatures upon the permeability of the various mixtures covered in this Paper in view of previous results obtained. In the first Paper* published it was clearly shown that the action of heat had very little effect upon the true permeability of mould and core compositions, and the apparent reduction in permeability was mainly due to the expansion of air inside the mould. The release of internal mould pressures caused by this factor is probably best catered for at the present time by suitably-placed risers and other artificial vents. This statement is made in view of the paucity of reliable information available relative to the action of protective washes employed in the production of castings in dry-sand moulds. There is a wide field of research open in this direction, and from investigations conducted by the writer it is indicated that the majority of foundrymen completely spoil the advantages likely to be gained from the use of permeable sands by effectively sealing surface permeability through the use of unsuitable mould washes.

Actual tests conducted upon this problem are given in Table VI, from which it will be observed that the most commonly used protective wash, made from clay-water, blacking and core gum, reduces the effective mould or core permeability from an A.F.A. number of 84 down to 29. This is by no means an exceptional result, as even lower values have been obtained. In one instance the author found a reduction in permeability from 85 down to 4.

The subject of this Paper does not permit further discussion of this aspect, but perhaps these few remarks will provide sufficient excuse for the statement relative to the provision of adequate risers and artificial vents. If the full advantages of this Paper are to be utilised, embracing as it does the addition of gas-producing elements to dry-sand compositions, it is most important to employ a wash which does not reduce the surface permeability of mould and cores. The elimination of the clay in the protective wash, and its substitution by a liquid or oil binder in conjunction with the use of the thinnest possible coat, results in the desired results being obtained, as indicated in Table VI.

In all the practical results conducted in connection with this present work the special sand mixtures having satisfactory high-temperature properties were protected with washes which did not appreciably reduce their surface permeability. As a matter of interest it might be pertinent to mention that from the results so far obtained it has been found that a sand having an A.F.A. permeability number not under 100,

* *Loc. cit.*

together with a loss on ignition not exceeding 10 per cent., will not " blow " when handled with normal foundry technique, even for the largest dry-sand castings.

In conclusion, one final word of warning in connection with the use of mould and core washes apart from their effect on permeability. It will no doubt be appreciated that it is no good developing a mould or coresand mixture having satisfactory characteristics at elevated temperatures unless the protective wash has similar properties. The usual wash composed of blacking plus clay-water, with or without the addition of a little core gum, etc., may be unsuitable for service with sands having a low expansion, as the wash may have a much greater expansion than the sand, and flaking is then liable to occur.

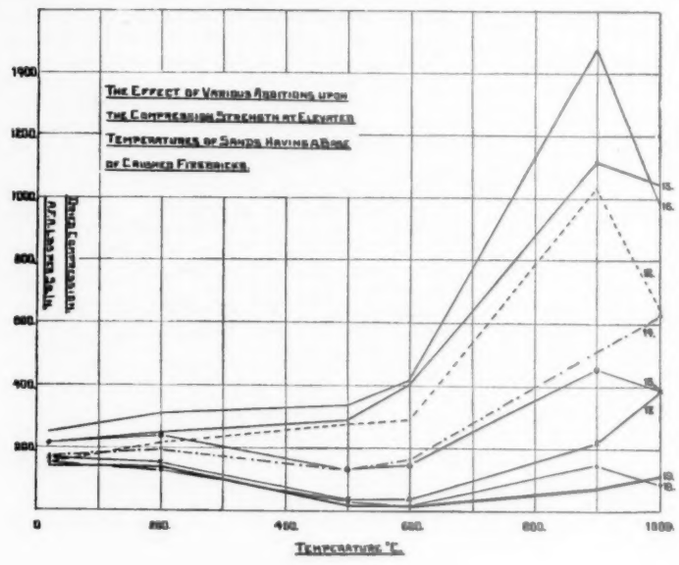

THE EFFECT OF VARIOUS ADDITIONS UPON THE COMPRESSION STRENGTH AT ELEVATED TEMPERATURES OF SANDS HAVING A BASE OF CRUSHED FIREBRICKS.
DRIED COMPRESSION
A.F.A. LBS. PER SQ. IN.
TEMPERATURE °C.

FIG. 12.

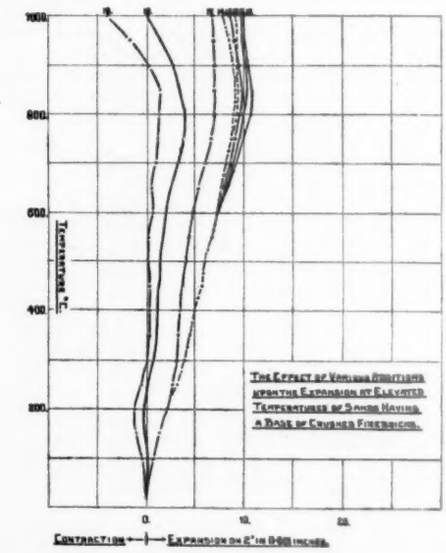

THE EFFECT OF VARIOUS ADDITIONS UPON THE EXPANSION AT ELEVATED TEMPERATURES OF SANDS HAVING A BASE OF CRUSHED FIREBRICKS.
TEMPERATURE °C.
CONTRACTION ← → EXPANSION ON 2" IN 000 INCHES

FIG. 13.

Satisfactory mould and core washes to operate with the mixtures outlined in this Paper must be, as previously mentioned, free from clay, and be composed preferably of a liquid or oil binder plus blacking, silica flour or any other protective medium employed. Such a mixture has high-temperature properties more approaching the base sands, has greater cohesion in the dried state, and does not tend to reduce the permeability so much as clay-bearing coatings.

The author desires to express his thanks to the directors of Messrs. Glenfield & Kennedy, Limited, and Mr. H. Gardner for permission to publish these results, and also to Mr. Lawrie, Mr. R. F. Hudson, and Mr. F. McCulloch for the valuable assistance received in conducting the various investigations in the foundry and laboratory.

Summary

The main points brought out by this investigation can be summarised as follow:—

(1) Many of the mould and core compositions used in the foundry trade have unsuitable properties at elevated temperatures.

(2) These unsuitable properties are characterised by:—(*a*) Excessive expansion and (*b*) large increase in strength both on heating and cooling.

(3) Such properties are detrimental to the production of sound castings as they cause:—(*a*) Surface " scabs " and sand " buckles "; (*b*) cracks, strains and inherent stresses; (*c*) hot tears and " pulls," and (*d*) dimensional inaccuracies between casting and pattern.

(4) By the use of suitable sand mixtures the three points stated above can be corrected. The results obtained indicate that a certain coal-dust addition imparts the necessary properties at elevated temperature to green sand. Sawdust additions are most satisfactory for dry sand and loam. In the case of brass and ironfoundry practice the above additions can be made to the existing base sand providing it has a suitable degree of permeability and is controlled by routine sand tests. The use of synthetic clay and liquid binders are strongly advised as a means for assisting control. Oil sand is also capable of giving good service when casting design permits. In connection with steelfoundry practice the above also applies, except it is preferable to use a synthetic sand made from crushed old firebricks in order to obtain the maximum satisfactory characteristics at elevated temperatures. The use of this latter sand may also be of value

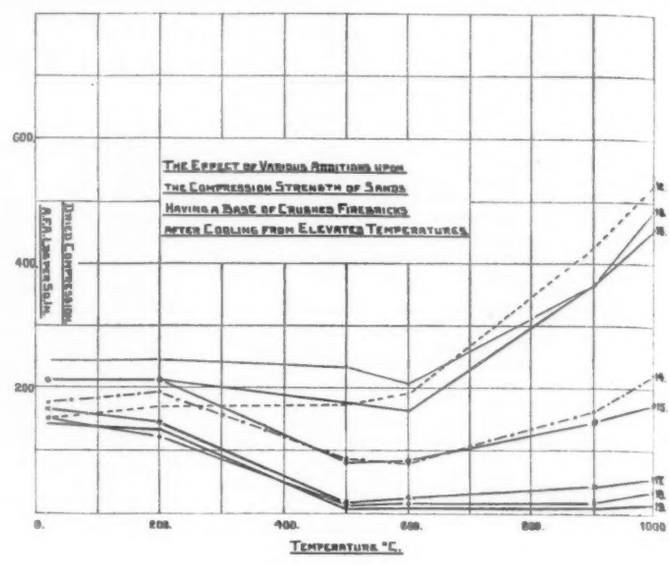

THE EFFECT OF VARIOUS ADDITIONS UPON THE COMPRESSION STRENGTH OF SANDS HAVING A BASE OF CRUSHED FIREBRICKS AFTER COOLING FROM ELEVATED TEMPERATURES.
DRIED COMPRESSION
A.F.A. LBS. PER SQ. IN.
TEMPERATURE °C.

FIG. 14.

TABLE V.—*Summary of the More Important Properties at Elevated Temperatures of the Sand Mixtures Investigated.*

Mixture No.	Total expansion per ft. on heating to 1,000 deg. C.		Max. compression strength obtained.	
	In.	Per cent.	A.F.A. lbs. per sq. in.	Temp., deg. C.
No. 1. Dry sand	0.152	1.27	640.0	900
No. 2. Dry sand + 5 per cent. coal dust	0.139	1.16	160.0	900
No. 3. Dry sand + 7½ per cent. coal dust	0.142	1.18	124.8	200
No. 4. Dry sand + 10 per cent. coal dust	0.128	1.07	83.2	200
No. 5. Dry sand	0.150	1.25	326.4	900
No. 6. Dry sand + 5 per cent. sawdust	0.094	0.78	44.8	200
No. 7. Dry sand + 7½ per cent. sawdust	0.010	0.08	24.0	20
No. 8. Dry sand + 10 per cent. sawdust	Contraction. 0.032	0.27	20.8	200
No. 9. Dry sand	0.153	1.27	512.0	900
No. 10. Dry sand + 5 per cent. sawdust	0.133	1.10	136.3	20
No. 11. Dry sand + 7½ per cent. sawdust	0.078	0.65	115.2	20
No. 12. Dry sand (made from firebricks)	0.058	0.48	1,030.0	900
No. 13. As above + 1 per cent. coal dust	0.062	0.52	1,120.0	900
No. 14. As above + 5 per cent. coal dust	0.055	0.46	624.0	1,000
No. 15. As above + 7½ per cent. coal dust	0.059	0.49	448.0	900
No. 16. As above + 5 per cent. blacking	0.065	0.54	1,472.0	900
No. 17. As above + 6 per cent. tar	0.042	0.35	384.0	1,000
No. 18. Specially-developed sand for steelfounding	0.009	0.07	151.2	20
No. 19. Specially-developed sand for steelfounding	0.023	0.19	141.8	20

for large iron castings when design or manufacturing methods warrant its use. The Paper also indicates the effect of other materials which can be alternatively added to promote better properties at elevated temperatures.

TABLE VI.—*The Effect of Protective Washes.*

Base sand used: Special dry sand containing 7½ per cent. sawdust.

Treatment.	App. den.	Per cent. moisture.	Compression strength. A.F.A. lbs. per sq. in. Green.	Compression strength. A.F.A. lbs. per sq. in. Dried.	Dried permeability. A.F.A. No.
Without protective wash	1.44	14.4	5.3	74.5	84
Usual foundry blackwash, 40 galls. clay water, 224 lbs. blacking, 9 lbs. dextrine or core-gum	1.44	14.4	5.3	73.6	29
Oil wash, 5 parts water, 1 part proprietary binder, enough blacking to form a thin cream	1.44	14.4	5.3	73.6	58
Special wash developed by G. & K.	1.44	14.4	5.3	60.8	89
Base sand used: Normal dry sand.					
Without protective wash	1.75	9.0	5.2	176.0	85
Usual foundry blackwash: Wash applied by operator A	1.75	9.0	5.2	148.2	5
" " B	1.75	9.0	5.2	131.8	5
" " C	1.75	9.0	5.2	129.6	4

TABLE VII.—*Effect of Clay Additions upon the Properties of Oil Sand at Atmospheric Temperatures.*

Mix. No.	Mixture composition.	App. density.	Per cent. moisture.	Compression strength, A.F.A. lbs. per sq. in. Green.	Compression strength, A.F.A. lbs. per sq. in. Dried.	Permeability A.F.A. No. Dried.	Per cent. loss on ignition.
20	97 per cent. dry sea sand, 3 per cent. linseed oil (raw), little water (milled 5 min.)	1.58	3.9	0.74	1,232	154	4.05
21	As above, plus 1 per cent. bentonite	1.55	4.6	1.3	488	147	4.09
22	As above, plus 2 per cent. bentonite	1.53	5.4	1.8	524	149	4.12
23	As above, plus 3 per cent. bentonite	1.53	4.8	3.1	307.2	152	4.30

NOTE.—Test cores dried for 1½ hrs. at 300 deg. F.

(5) To obtain the full benefits of these special mixtures the protective wash used must have similar properties at elevated temperatures as the base sand. The majority of protective coatings at present in service are not satisfactory and it is considered that a simple mixture of some liquid or oil binder plus blacking, etc., is preferable to washes containing clay.

(6) In regard to permeability of the sand, this is indirectly affected by the action of heat, due to the expansion of air inside the mould, and the pressure so generated is best relieved by adequate risers and artificial vents. At the same time it is advisable to use permeable sands, provided the protective coating employed does not reduce the permeability to any appreciable extent.

(7) The results obtained indicate the need of further research in at least two directions:—(*a*) Effect of composition on the properties of oil-sand mixtures at elevated temperatures; (*b*) effect of composition on the properties of mould and core protective washes at atmospheric and elevated temperatures.

APPENDIX

Effect of Clay Additions upon the Properties of Oil Sand at Elevated Temperatures

Since these experiments were made, further tests have been completed on the effect of clay additions upon the properties of oil sand at elevated temperatures, and in view of the interesting results obtained it was decided to offer them as an appendix.

Table VII indicates the sand mixtures employed and their respective properties at atmospheric temperatures.

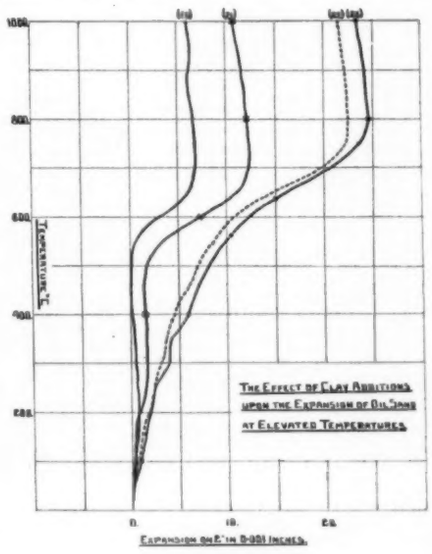

THE EFFECT OF CLAY ADDITIONS UPON THE EXPANSION OF OIL SAND AT ELEVATED TEMPERATURES.
TEMPERATURE °C.
EXPANSION ON 8" IN 0-001 INCHES.

FIG. 16.

Figs. 15, 16 and 17 show the results obtained at elevated temperatures and Table VIII gives a summary of the more important properties as a continuation of Table V. Perhaps the most striking point of interest is in connection with the effect of clay upon the expansion of oil sand. In many instances it has been found necessary in practice to incorporate a certain percentage of clay or bonded sand in oil-sand mixtures for reasons connected with the type of castings being made and other production requirements. It will be observed that the straight sea sand-oil mixture has quite a low expansion on heating, but this is most markedly increased by the addition of clay. The reason for this is quite obviously connected

(*Concluded on page* 510.)

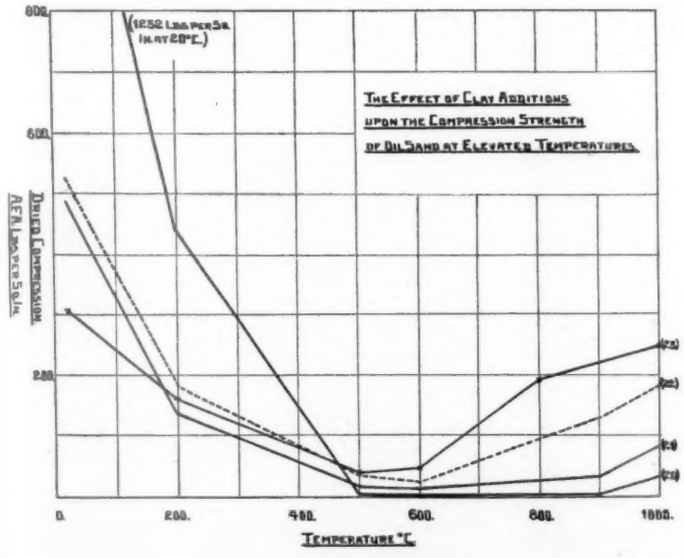

THE EFFECT OF CLAY ADDITIONS UPON THE COMPRESSION STRENGTH OF OIL SAND AT ELEVATED TEMPERATURES.
DRIED COMPRESSION A.F.A. LBS. PER SQ. IN.
TEMPERATURE °C.

FIG. 15.

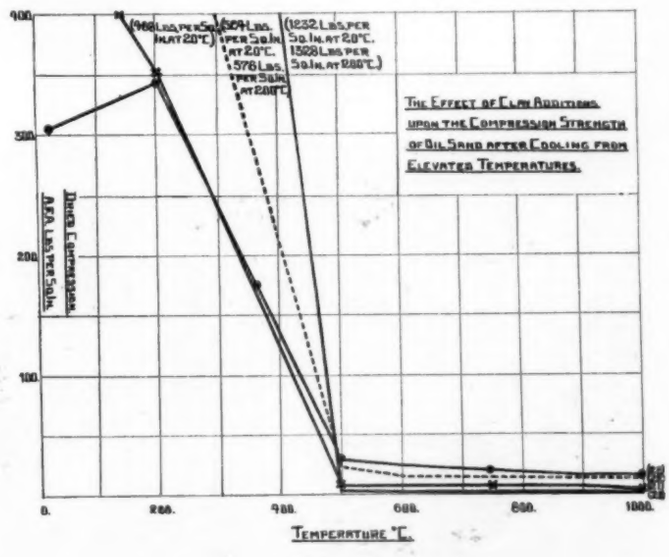

THE EFFECT OF CLAY ADDITIONS UPON THE COMPRESSION STRENGTH OF OIL SAND AFTER COOLING FROM ELEVATED TEMPERATURES.
DRIED COMPRESSION A.F.A. LBS. PER SQ. IN.
TEMPERATURE °C.

FIG. 17.

New Spun Plant for Cast-Iron Pipes

WORKS OF COCHRANES (MIDDLESBRO') FOUNDRY, LIMITED

The Ormesby Iron Works have been held in esteem for the manufacture of cast-iron pipes for well over three-quarters of a century. It was in 1854 that the late Mr. Alexander Brodie Cochrane left South Staffordshire and established a works on the present site when he built four blast furnaces and laid down a large pipe-moulding shop. In 1861 the pipe foundry became a separate company under the style of Cochrane, Grove & Company, continuing under this control until 1902 when it was amalgamated with Cochrane & Company, Limited.

FIG. 1.—GENERAL VIEW OF PLANT (CUPOLA SIDE).

The site possesses exceptional facilities for transport; it is, of course, directly connected with the railway and at the same time has a frontage of 1,000 ft. on to the River Tees. At the company's wharf, ships up to 5,000 tons can be berthed, whilst the docks of the railway company, which are adjacent to the works, provide berthing for the largest freight-carrying ships.

From the outset the pipe foundry proved an unqualified success, frequent extensions being made to plant and buildings until the annual output was approximately 80,000 tons of pipes per annum. At this time sand casting was the only practical method of producing cast-iron pipe and, indeed, this system remained unchallenged until about 14 years ago when the Stanton Company adopted the Sensaud de Lavaud process of centrifugal casting and finally developed this process practically and commercially. Following upon the pioneer work of the Stanton Company, with the de Lavaud process came the centrifugally sand-cast pipe, and it seemed apparent that pipe casting in the near future would be mainly, if indeed not wholly, on the centrifugal principle.

The directors of the Ormesby Works, not lacking in imagination or initiative, at once determined to try out the centrifugal system on commercial lines, and some five years ago three spinners for centrifugal casting were installed. Up to this time "chill" was unavoidable when casting with the de Lavaud process and had to be removed by normalising. From the outset it was recognised that if the castings could be produced without chill a very material advance would be made in the forward direction. For a number of years Cochranes have been developing the Mairy ferro-silicon process, with which, in combination with the de Lavaud system of casting they have succeeded in producing a cast pipe which has not inappropriately been called Cochranes Super-Spun iron pipe. It remained only to enter into an arrangement with the Stanton Ironworks Company, Limited, for a mutual exchange of licences to operate the patents governing the Mairy process and the de Lavaud system, an arrangement which has enabled the two companies concerned to effect a notable advance in the manufacture of cast-iron pipes.

The Mairy Process

The Mairy process consists of applying a thin coating of ferro-silicon in the revolving steel mould before the metal is introduced. This deposition forms an insulating surface on the mould and prevents the formation of chill. The resulting casting combines the high tensile strength of the original de Lavaud pipe with a greatly-

FIG. 2.—GENERAL VIEW OF MACHINES.

FIG. 3.—BATCH OF SOCKET CORES.

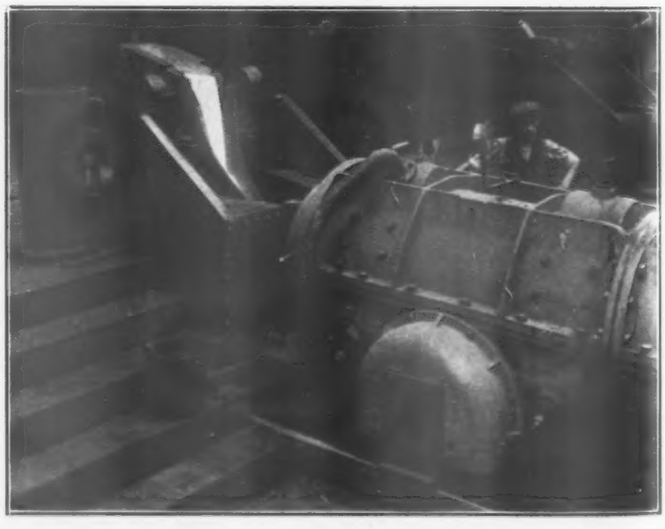


FIG. 4.—BEGINNING OF CASTING.

increased ductile strength and resistance to shock. That the pipes so produced are free from "chill" was demonstrated in the experimental installation, as the pipes fulfilled all standard requirements as to tests, and this without any form of normalising. A fracture of the pipe discloses a two-zone structure, the outer zone consisting of closely-interlocked dendrites in multi-directional formation, giving high ductile strength or impact resistance, and an inner zone having a characteristic centrifugal structure with finely-dispersed graphite, producing high tensile strength.

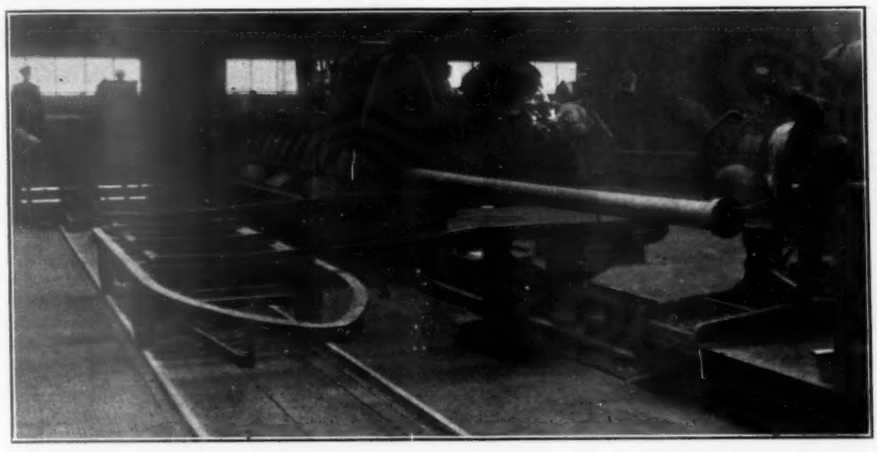


FIG. 5.—PIPE BEING WITHDRAWN.

It is claimed that the pipes now made by the improved process possess greater ductile and tensile strength than any cast-iron pipes previously produced. Judged from a sledge-hammer point of view the strength is about five times that of the ordinary centrifugally-cast pipe and fully double that of the sand-cast pipe, which of course is very much thicker in section.

The manufacture of centrifugally-cast pipes is obviously a highly-specialised industry which demands the very careful planning of a self contained works and it was with a generous recognition of these facts that the directors of Cochranes (Middlesbro') Foundry, Limited, tackled the proposition.

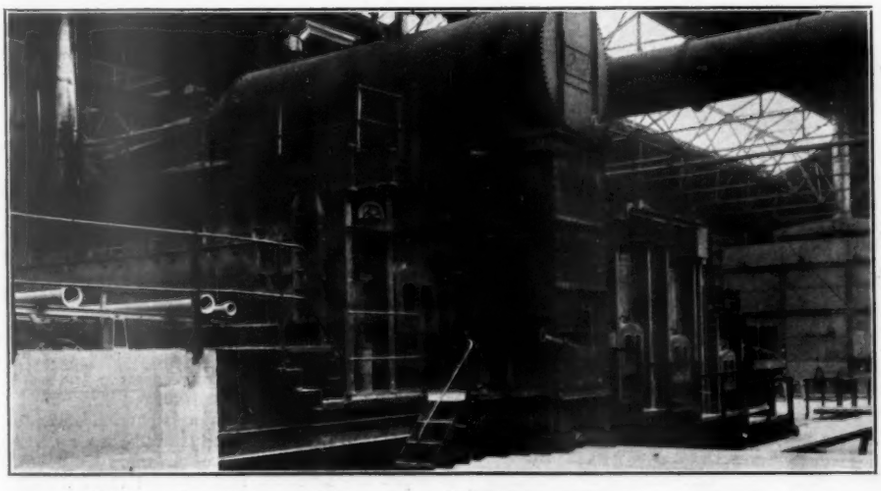


FIG. 6.—SIDE VIEW OF NORMALISING FURNACE; PIPES ENTERING ON LEFT.

LAY-OUT OF WORKS

The blast furnaces were dismantled and a considerable portion of the old shops pulled down to provide the necessary space for an entirely new foundry and the storage accommodation incidental thereto. The new foundry, which was formally opened by the Marquis of Londonderry, K.G., P.C., M.V.O., on the 13th inst., places Cochranes in the front rank of European cast-iron pipe manufacturers. It enables them to produce pipes from 3 in. to 24 in. dia. and in lengths of 12, 18 and 21 ft. The general layout is a distinctly imposing one. Every foot of space has been turned to account, but everywhere there is ample room. A works of this nature does not of course lend itself to extensive mechanisation but by a careful disposition of the units in the layout, the pipes pass through the works with a minimum of handling.

Melting Plant

The layout of the melting plant is characteristic of the whole works. From the reception of the raw materials to the pouring of the metal, the arrangements could not be more simple and it is certainly not easy to visualise a more efficient system. The stocking ground, immediately at the rear of the cupolas is served with two lines of wagon roads, with stocking space between them. The ground is spanned by a 5-ton Vaughan crane, which also handles an Allen West magnet. Coke and limestone are brought in on the track nearest the cupolas, pig-iron and scrap being brought in on the outer track.

Four cupolas are housed on a common platform, these having been built by the Constructional Engineering Company, Limited. Needless to say these are of the most modern type, with drop bottoms, two of the cupolas being of 12 tons and two of 7½ tons, melting capacity. Melting is continuous into receivers of the teapot-spout type, which are mounted on trunnions and tilted by means of hand-wheels operating through gear. Blast is supplied by motor-driven fans by Keith Blackman and Alldays & Onions manufacture. Spare ladles are carried in a lean-to adjoining the melting plant and producer gas is laid on for heating purposes.

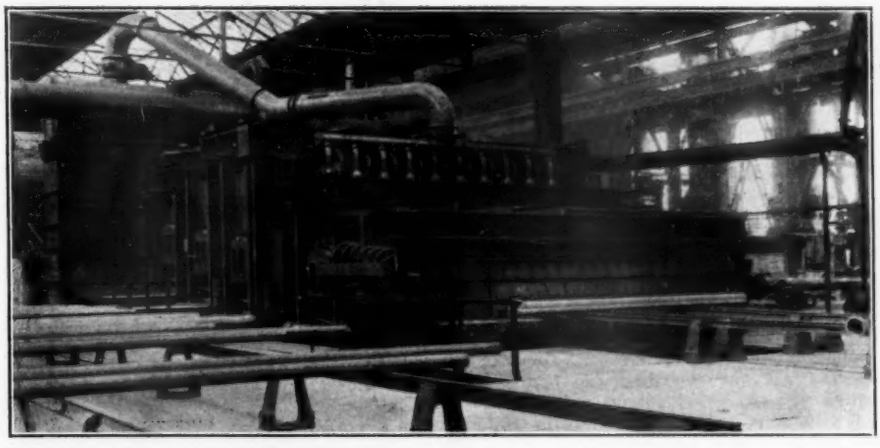


FIG. 7.—EXIT END OF NORMALISING FURNACE SHOWING FEED PIPES TO GAS BURNERS.

Charging Arrangements

Whilst, as already stated, provision is made for carrying stock, normally the wagons bringing the pig and scrap are discharged direct into a 2-ton scoop skip which is then lifted by the crane to the charging level of the cupolas. The cupolas are charged by way of shutes, the outer ends of these shutes being furnished with a raised horizontal bar which is engaged by a hook member beneath the skip; the contents of the last named are thus discharged direct into the cupola, automatically.

From the receivers the metal is tapped into Jackman 50-cwt. ladles. Two of these ladles are always in service; they are suspended from 5-ton cranes which run on a telpher in front of the cupolas, over the casting points for the moulds and thence at the rear of the casting platform and cupolas back to the receivers for a further burden, thus melting, pouring and casting have been reduced to a time factor and the operations are performed with the smoothness of a well-balanced machine.

The Spinners

The spinners, as the centrifugal casting machines are more generally called, stand side-by-side with the melting plant, the six machines being arranged in line. It will no doubt be of interest if we deal briefly with the features and functioning of the casting machine. In the first place the pipe is cast in an accur-

ately-machined steel mould which is revolved on its own axis through gearing by a motor placed on the outside of the water-cooled casing. The mould is supported at two points in its length by friction rollers with bearings on the inside of the casing. Grease-cup lubrication is effected from the outside of the casing. Through the annular space between the casing and the cylinder, water is circulated at a constant temperature and pressure, by means of thermostatic control. The casing with its revolving mould is traversed to and fro along its slightly-inclined bedplate by means of a hydraulic cylinder. Metal is fed into the mould by means of a cantilever trough and a tilting ladle.

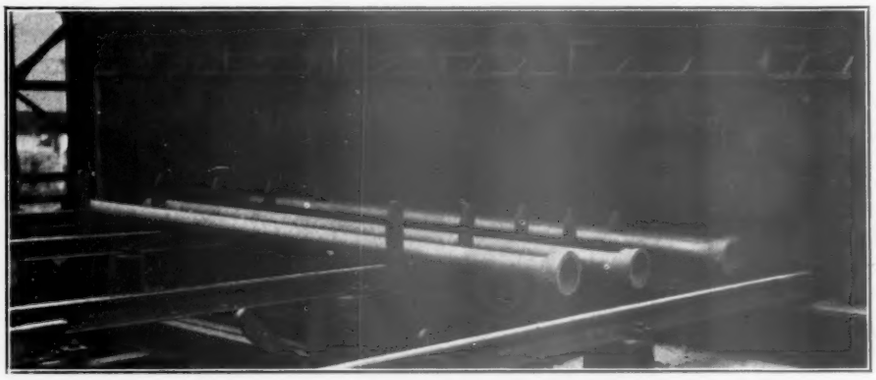


FIG. 8.—PIPES ENTERING NORMALISING FURNACE.

The method of spinning is as follows:—The casing, with its mould, into which the socket core has been fitted, is moved up to the tilting ladle. The cantilever trough is thus caused to enter the mould and position itself adjacent to the socket end. The tilting ladle receives its charge from the large ladle, a charge always slightly in excess of the metal required for the pipe being cast. The mould is started up by push-button and when the proper speed has been reached, the tilting ladle is tipped and the metal flows down the trough. On a signal from the man at the discharge end of the machine that the socket portion of the mould is filled with metal, the casing is traversed away from the ladle at a definite speed. When the mould reaches its extreme position it is clear of the end of the trough and any excess of metal is discharged into a receptacle at the side of the machine. Spinning is continued for a few seconds in which time the metal has solidified. The pipe is then withdrawn from the mould by engaging the socket with a pair of special internal pipe grips and allowing the machine to travel back to the casting position. As the machine moves backward a pair of arms move outwards and across the machine track at right-angles, these receiving the pipe and transferring it to the pipe carriage. One of these carriages serves each pair of spinners; they are each rope driven by a 5-h.p. motor, with reversing controller. The carriage, when it is moved forward, pushes back gate members in the pipe gantry feeding the normalising furnace, the pipes being rolled off from the carriage to the gantry. As the carriage moves away, the gates close automatically and thus form a portion of the gantry, making it continuous for the line of machines.

The socket cores are knocked out over a grid and the sand falling upon a conveyor is delivered outside the foundry to a bucket elevator which raises it to a sufficient height to be fed by way of a breeches shute into hopper buckets which are handled by the crane and discharged into wagons for delivery to the dump.

Normalising Furnace

Since there is no "chill" to be removed, the pipes are passed through a normalising process merely to toughen them; in a word, the manufacturers are doing everything possible to justify their claim to "Super-Spun." The furnace, built by Priests Furnaces, Limited, of Middlesbrough, is, even considered for the heavy duty it must perform, of exceptionally massive design, being 59 ft. long by 25 ft. wide inside dimensions, and is designed for treating pipes up to 24 in. dia. It is heated by clean producer gas, 150 B.T.U., which is supplied from the central producer plant of the works.

The pipes are rolled through the furnace at a predetermined speed which is regulated by means of a chain conveyor fitted with heat-resisting steel fingers which correctly space the pipes. The heating is arranged on the counter-flow principle, ensuring peak economy and correct heating cycle for the pipes which pass through preheating, soaking and cooling zones respectively. The waste gases leaving the furnaces are divided into suitable proportions so as to pass part through a gas recuperator and the remainder through the pipe reheating stove and from thence under the dipping tanks; the gases thus enter the waste-gas chimney at very low temperatures.

FIG. 10.—VIEW OF GANTRIES.

FIG. 9.—PIPE-HEATING STOVE FOR DIPPING PROCESS.

From the outgoing side of the normalising furnace the pipes are rolled on to a transfer carriage and transferred therefrom to the gantries serving the grinding and testing machines, etc. A section of these gantries is carried on a weighbridge, pipes being weighed and examined before passing to the battery of grinders by which the pipes are scrubbed and cleaned inside.

Reheating Furnace

The pipes are tested hydraulically and afterwards pass on a continuation of the gantry through the reheating furnace in which they are brought up to the correct temperature for dipping. The furnace is 31 ft. 6 in. long by 23 ft. wide by 4 ft. 6 in. high, designed to accom-

(*Concluded on page* 510.)

An Extension of the STANTON *Metallurgical Service*

CONSULTATIONS with an expert in foundry technique who will, if desired, visit your own foundry, are a feature of the extended advisory service offered by the Stanton Company. Such visits are additional to, and quite distinct from, the ordinary calls made by sales representatives, the subjects discussed covering the whole field of foundry practice.

All queries, whether they require a personal visit or can be answered by post, will be attended to promptly and individually by a qualified metallurgical staff. The service is intended to benefit both users and producers of pig-iron by helping to improve the properties of cast-iron, so extending its field of use.

Both as ironfounders whose cast-iron products are used in all parts of the world, and as the largest producers of foundry pig-irons (for sale) in Great Britain, the Stanton Company have many years' experience of metallurgical problems. Through the medium of the advisory service this experience is placed at the disposal of the foundry industry.

Much information constantly needed by the foundryman appears in concise form in the Stanton pig-iron handbook which will gladly be sent on request. It contains useful cupola data and photographs of fractures, microphotographs and analyses of all Stanton pig-irons—including Stanton, Holwell and Rixons (W'bro') brands.

THE STANTON IRONWORKS COMPANY LIMITED
Near NOTTINGHAM

modate 24-in. dia. pipes 21 ft. long. As previously stated this furnace is heated by a portion of the waste gases from the normalising furnace. Auxiliary burners are, however, fitted at the front end remote from the dipping tank whilst suitable gas, air and waste-gas controls are arranged to ensure uniform heating.

The dipping tank 24 ft. long by 11 ft. wide by 6 ft. deep is supported on a multiplicity of walls which form the sides of heating flues and are disposed so as to give a uniform heat over the full length and width of the tank. The normalising furnace, the reheating stove and the tank were designed and built by Priest Furnaces, Limited, of Middlesbrough, the mechanical equipment of the dipping tank being supplied by Vaughan of Manchester. The arrangement of utilising the available waste heat ensures maximum economy of fuel and at the same time gives a plant with accurate control and a steady uninterrupted production of first-class pipes of uniform quality.

Beyond the dipping tank are the wrapping gantries from which the pipes are loaded up

FIG. 11.—PIPES BEING SCRUBBED.

for despatch or passed into stock, as the case may be. The gantry of the stocking ground, 500 ft. in length, is served with a 7½-ton overhead electric crane.

A section of the shop is laid off for the production of socket cores, sea sand being used. The sand is brought in by railway wagon and bottom-discharged through a grid into a below-ground hopper from which it is raised by a bucket hoist and delivered to a mixer by the Fordath Engineering Company, Limited. After mixing, the sand is discharged into a transporting hopper from which it is fed by way of shutes direct to the moulding bench. Aluminium core boxes are employed and the sockets are made on hand-operated jolt machines.

The core stove is of the continuous type, built by Foundry & Engineering Company, Limited, of West Bromwich. Drying is by hot air from a coke-fired furnace. A core passes through the oven in a period of two hours. A separate room houses three Harland Engineering Company centrifugal pumps, each driven by a 7-h.p. motor, for circulating the cooling water. The motors throughout the works are of Crompton-Parkinson manufacture, whilst the control gear is mainly by Brookhirst Switchgear, Limited. The fans on the furnace and stove are Sirocco by Davidson & Company, Limited.

A separate building is laid off for mould turning, in which are installed three lathes of 18-in. centres with beds 42 ft. long; they are independently motor driven and are served by a 5-ton Vaughan crane.

British Chemical Plant Exhibition

In conjunction with the Chemical Engineering Congress of the World Power Conference being held in London, June 22 to 27, a British Chemical Plant Exhibition has been arranged in Central Hall, Westminster, where meetings in connection with the Congress are taking place. We append a few of the exhibits likely to be of interest to some of our readers:—

British Oxygen Company, Limited, London.—Oxy-acetylene welding equipment for effecting joints in ferrous and non-ferrous metals. Oxy-acetylene welding rods and fluxes for making joints, building up worn surfaces, for hard surfacing prior to service and for applications of corrosion-resisting metals. Lead-burning equipment. Examples of actual work carried out by oxy-acetylene welding in ferrous and non-ferrous metals.

Firth-Vickers Stainless Steels, Limited, Sheffield.—A range of acid, chemical and heat-resisting steels as developed by Firth-Vickers Stainless Steels, Limited, for chemical plant and for equipment in the food, dairy and such like industries. The exhibits are fully technical, demonstrating the various processes involved in the fabrication of plant together with complete physical and chemical corrosion test data. Numerous examples of plant made from "Staybrite" acid-resisting steel are shown, and particular attention is drawn to the manufacture of plant from "Staybrite" F.D.P. the disintegration-proof, acid-resisting steel, which needs no heat-treatment after the making of welded joints.

Samuel Fox & Company, Limited (associated with the United Steel Companies, Limited), Sheffield.—Welded containers and samples of plates and bar in "Silver Fox" new process stainless steels, showing ease of manipulation and weld-decay-free steel capable of taking a high polish.

Hadfields, Limited, Sheffield.—Specimens of articles made of Hadfields "Era" C.R. corrosion resisting steels, steels which offer a high resistance to the action of many chemical agents, and of "Era" H.R. heat-resisting steels which have a high strength and do not scale when subjected to high temperatures; a modern autoclave, of 2 litres capacity, to work at temperatures up to 450 deg. C. and 250 atms. pressure, the vital parts of which are of Hadfields forged "Hecla 134" alloy steel, designed and built at the Chemical Research Laboratory, Department of Scientific and Industrial Research, Teddington. A model of a Hadfield "Hecla" disc crusher, a type of machine extensively used for reducing all classes of stone and ores to a moderately fine product is being shown.

International Combustion, Limited, London.—Exhibit of grinding and screening plant. The two major exhibits are—(*a*) a constant weight feeder; and (*b*) a Raymond mill model. The former takes the form of a balanced endless belt, which conveys or feeds loose material to grinding mills or similar plant. The Raymond mill model will show the degree of extreme fineness and uniformity to which a raw material may be ground. The screen section is represented by a "Junior Hum-mer" an electrically vibrated screen measuring 20 in. by 30 in. and may be operated by A.C. lighting supply. Other prominent exhibits are, special rubber-lined Vac-seal pump to deal with abrasive slurries, and a "Rotap" testing sieve shaker, which provides mechanical accuracy for laboratory screen tests.

Composition and Its Effect upon the Properties of Mould and Core-Sand Mixtures at Elevated Temperatures

(*Concluded from page* 505.)

with the fact that a sand having its grains bonded with oil alone is unstable at high temperatures, and it is highly probable that the removal, or partial removal, of the organic bond will cause a contraction to offset the expansion of the silica grains themselves. The addition of clay will tend to prevent this contraction taking place and the expansion of each grain of sand will consequently be transmitted to the whole mass.

TABLE VIII.—*Summary of the More Important Properties at Elevated Temperatures in Connection with the Effect of Clay Additions to Oil Sand.*

Mixture No.	Total expansion per ft. on heating to 1,000 deg. C.		Max. compression strength obtained.	
	In.	Per cent.	A.F.A. lbs. per sq. in.	Temp. deg. C.
20 Oil sand ..	0.040	0.33	1,232.0	20
21 Oil sand— 1 per cent. clay	0.074	0.615	488.0	20
22 Oil sand— 2 per cent. clay	0.135	1.125	524.0	20
23 Oil sand— 3 per cent. clay	0.147	1.225	307.2	20

The effect of clay additions upon the compression strength, both at temperature and on cooling from temperature, are of interest in consideration with the other data given. Probably the point of most value shown by these later tests is the omission by the author to include the effect of clay, as applied to ordinary mould and core compositions, in this Paper. As is usually the case, one is apt to overlook the obvious, but this point is well worthy of attention. However, there is no doubt that the text of this Paper will receive greater future consideration by all those who investigate and study the subject of foundry sands, and the author confidently looks forward to not only seeing confirmation of these results, but also to the correction of any omissions there may be.

Catalogue Received

Special Alloy. I.C.I. Metals, Limited, Kynock Works, Witton, Birmingham, 6, have done a real service to the foundry industry in their publication entitled "Everdur," as on page 42 and those which follow they give a number of essentially practical hints. These include the technique of melting, moulding, gating and pouring; casting temperature; remelting scrap; heat-treatment; and pattern allowances.

The alloy dealt with is a copper-silicon-manganese "bronze," possessing anti-corrosive properties. It is ductile; has a high fatigue limit and good machinability and is weldable. These claims and many others are supported by a mass of published data. If those exploiting new alloys would only emulate the method set out in this booklet, the literature of metallurgy would be materially enriched. The brochure is well illustrated and runs to 46 pages.

ROWLAND

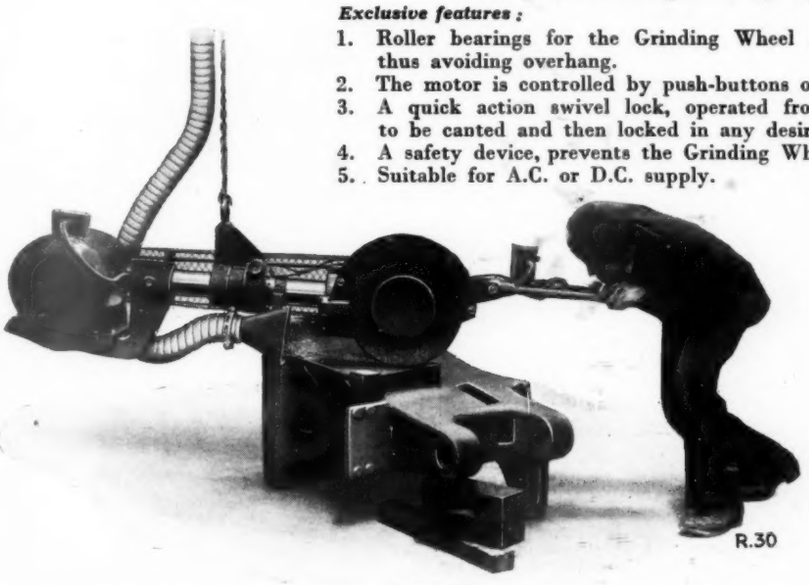
HIGH SPEED PORTABLE GRINDER

This is an entirely new High Speed Grinder, for fettling castings which cannot be handled.

It is quick and light to operate, yet sturdy, of build.

Exclusive features :

1. Roller bearings for the Grinding Wheel are located inside the Wheel collet, thus avoiding overhang.
2. The motor is controlled by push-buttons on the handle-bars.
3. A quick action swivel lock, operated from the handle-bars enables the Wheel to be canted and then locked in any desired setting.
4. A safety device, prevents the Grinding Wheel being run at an incorrect speed.
5. Suitable for A.C. or D.C. supply.



All foundries should have particulars of this new machine.

F. E. ROWLAND & CO., LTD., Climax Works, REDDISH, STOCKPORT

LONDON : H. C. Amos & Co., 22, Martin Lane, Cannon Street, LONDON, E.C.4
N.E. Coast : T. Feather, Esq., 16, Devonshire Place, Jesmond, NEWCASTLE-on-TYNE.
MIDLANDS : L. Williams, Esq., 31, Parkside, COVENTRY.
SCOTLAND : Wilson Feather & Son, 122, Wellington Street, GLASGOW.

With their world-famous reputation ever in mind Messrs. Leyland Motors Ltd. rather naturally make extensive use of Warner Special Pig Irons in the production of their Cylinder Blocks.

May we quote against *your* specification ?

WARNER & CO. LIMITED, CARGO FLEET, MIDDLESBROUGH

The Week's News in Brief

Trade Talk

AN EXTENSION to the premises of James H. Lamont & Company, Limited, Gylemuir Works, Corstorphine, engineers and brassfounders, Edinburgh, was formally opened on June 16.

A LAST-MINUTE POSTPONEMENT of the 15th Annual Congress of the French Foundrymen's Association is announced. It was to have opened to-morrow at Lille. The rearranged date has not yet been fixed.

A NEW COMPANY has been formed at Belgrade, under the name of Aluminij, for the manufacture of aluminium, with financial assistance from the State. The factory will be established at the Krka Waterfall, near Sibenik.

AS "ESCOL" ENAMELS were used in the decoration of the "Queen Mary," James Gray & Sons, Limited, of 5, Victoria Street, London, S.W.1, have presented to many of their clients a coloured picture of the giant liner. It is a very pleasing reproduction.

JOHN M. HENDERSON & COMPANY, LIMITED, of King's Works, Aberdeen, have received orders for two 80- to 100-ton overhead cranes from Davy Bros., Limited, Sheffield, and a 5-ton overhead crane from Thomas Firth & John Brown, Limited, Sheffield. These cranes are to be provided with enclosed gears and fitted with ball-bearings throughout.

THE SUFFOLK IRON FOUNDRY (1920), LIMITED, have just completed negotiations for the purchase of a complete factory, situated in the London area, for the manufacture of carpet sweepers and small rubber wringers. It is their intention immediately to erect a modern wood-working factory at Stowmarket, and they hope to have it in full production before the end of the year.

REPRESENTATIVES of the executives of 37 engineering industry unions at York last week accepted the offer of the Engineering Employers' Federation for an amendment in wages by which the war bonus is increased by 3s. a week to all adult male workers. The first shilling is to be payable in the week beginning June 29, the next shilling in the week beginning September 28, and the third shilling in the week beginning December 28.

THE FIRM of A. Reyrolle & Company, Limited, last week celebrated its jubilee. The company was founded in 1886 by the late Mr. A. C. Reyrolle in a small switchgear workshop in London. In 1901 the business removed to Hebburn. The original site comprised 5½ acres; but extensions have been made until an area of 57 acres has been reached. The employees now number 4,000, as against 10 when the firm commenced. J. H. Holmes & Company, Limited, are incorporated with Reyrolle's, while in 1934 the Parolle Electric Plant Company was formed, associating C. A. Parsons & Company, Limited, of Newcastle, with the Reyrolle organisation.

Diamond Wedding

Mr. and Mrs. W. H. Sherburn, who were married as long ago as 1876, celebrated their diamond wedding on June 20, and received a congratulatory message from His Majesty the King. Mr. Sherburn is a life member of the Institute of British Foundrymen, having joined in 1907. He received the Oliver Stubbs medal in 1923 for a Paper on "The Evolution of the Foundryman," which showed that throughout the ages the spirit of Benvenuto Cellini had animated the true craftsman. Mr. Sherburn was born in Rotherham in 1853, and was apprenticed to patternmaking, and being associated with the stove and grate trade it gave an opportunity to develop the artistic side of his nature in the creation of designs for overmantels and the like. When 30 years of age he joined the firm of Fletcher Russell & Company, Limited, of Warrington, and was a pioneer in the development of the gas fire section of the industry. To-day he is still retained by Richmonds—an associated firm—in a consulting capacity. He and Mrs. Sherburn have been the recipients of many congratulatory messages, and to these we desire to add our own. May they still have long years of happy retirement.

Birthday Honours

Three names which are well known in foundry circles appear in the list of Honours conferred on the occasion of His Majesty's Birthday. SIR HERBERT AUSTIN, K.B.E., M.I.Mech.E., J.P., the chairman of Austin Motor Company, Limited, has been created a Baron. He has on several occasions been the guest of the Institute of British Foundrymen. MR. H. N. GRESLEY, C.B.E., D.Sc., M.I.Mech.E., M.I.E.E., chief mechanical engineer of the London & North Eastern Railway, has been created a Knight Bachelor, and MR. F. J. WEST, C.B.E., M.Inst.C.E., M.I.Mech.E., J.P., has also been created a Knight. Mr. West, an ex-Lord Mayor of Manchester, has also been a principal speaker at an annual banquet of the Institute of British Foundrymen. He is a Past-President of the Manchester Association of Engineers.

Company Reports

International Combustion, Limited.—Interim dividend of 7½ per cent. on the ordinary shares.

Electric Construction Company, Limited.—Net profit, £35,114; brought in, £6,461; dividend on the ordinary shares of 7 per cent.; carried forward, £16,181.

Barrow Hæmatite Steel Company, Limited.—Loss after payment of prior lien short-term note interest for the full year and interest on debenture stock for the second half of the year, £12,812; debit balance brought in, £14,946; debit carried forward, £27,758. Meeting, June 26.

James Keith & Blackman Company, Limited.—Available, after providing for payment of preference dividend, and making allowance for depreciation and reserves against doubtful debts, £39,035; dividend on the ordinary shares of 15 per cent., £22,875; written off freehold land and buildings, Arbroath, £3,000; transferred to reserve account, £3,000; carried forward, £10,160. Meeting, June 26.

Allied Ironfounders, Limited.—Revenue from trading, £259,730; other income, £5,772; tax refund, £1,919; debenture interest, £3,501; directors' commission, £6,437; net profit, £257,483; brought in, £124,767; preference dividend, £53,522; tax reserve, £7,500; to obsolescence, etc., £15,000; to research reserve, £10,000; to general reserve, £25,000; ordinary dividend of 10 per cent., £124,818; carried forward, £146,410.

Edgar Allen & Company, Limited.—Accounts show a credit balance (after making provision for income tax to the extent of £7,500 on the profits of the year) of £32,182; brought in after deduction of dividends paid on cumulative preference shares for year to March 31, 1935, £26,658; dividend on preference shares for year to March 31, 1936, £11,625; dividend on the ordinary shares of 5 per cent., £10,953; to general reserve, £12,500; carried forward, £23,762.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Autometric Pumps, Limited, 84, Chancery Lane, London, E.C.4.—Capital, £1,000. Directors: A. A. Mercer and G. H. Humphreys.

H. Perks & Company, Limited, The Foundry, Stanley Road, Harrow.—Capital, £3,000. Foundry proprietors and engineers. Directors: H. C. Perks and S. L. Witton.

Contracts Open

Douglas, June 30.—Iron and steel, for the Town Council. The Borough Surveyor, Town Hall, Douglas, Isle of Man.

Godalming, June 30.—600 yds. 6-in. cast-iron water main and specials in 18-ft., 12-ft. and 9-ft. lengths, for the Town Council. Mr. E. G. Bowyer, waterworks engineer, 35, Bridge Street, Godalming. (Fee £1 1s., returnable.)

Personal

MR. HORACE BOOT, a well-known industrialist, has been elected Master of the Worshipful Company of Cutlers.

MR. FRANK S. RUSSELL, chairman and managing director of General Refractories, Limited, has returned from an extensive Continental business tour.

LORD RIVERDALE was presented with a portrait of himself, painted by Mr. Harold Knight, R.A., at a private dinner of members of the Cutlers' Company at the Cutlers' Hall, Sheffield, on June 11. The presentation was made by the Master Cutler, Sir Samuel Roberts.

GLASGOW UNIVERSITY has conferred the honorary degree of Doctor of Laws on Prof. Alexander Lawson Mellanby, Professor of Civil and Mechanical Engineering, at the Royal Technical College, Glasgow. Prof. Mellanby delivered the second Edward Williams Lecture to the Institute of British Foundrymen at the recent annual conference in Glasgow.

MR. FRANK W. ROBINSON, who for some time has been representative in Lancashire, part of Cheshire and the West Riding of Yorkshire of Thos. W. Ward, Limited, has been appointed assistant manager of the foundry supplies department. His district is being taken over by Mr. G. B. Allwood, who has been transferred to Manchester. Mr. Allwood is succeeded by Mr. Arthur Moore, who for some time has been engaged on the commercial side of the foundry supplies department at the firm's head office.

Wills

HALL, R., formerly of Robert Hall & Sons (Bury), Limited, ironfounders, Bury... £18,748

Obituary

MR. W. NORMAN PAYNE, elder son of Mr. Charles Payne, managing director of Harland & Wolff, Limited, has died from injuries received in a motor accident.

MR. WILLIAM FAWCETT OSBORN, chairman of Samuel Osborn & Company, Limited, of Sheffield, died at Sheffield on June 16. Mr. Osborn, who was 75 years of age, was made a partner in the company in 1885, and has been chairman since it was converted into a private limited company in 1905. He has been a member of the Cutlers' Company since 1891 and was elected Master Cutler in 1906. He was also a member of the council of the Sheffield Chamber of Commerce for many years. He became a magistrate for the West Riding in 1906 and for Sheffield in 1912. Mr. Osborn was also a director of High Speed Steel Alloys, Limited, Widnes.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"MICROLOY."—Piston rings. C.M.D. Engineering Company, Limited, Wharf Street, Warwick.

"H.J.T." (DEVICE).—Pressure die castings of zinc, tin, lead, brass and aluminium alloys. Herbert J. Thormann, 5, Perren Street, London, N.W.5.

"CELILYND."—Unwrought and partly wrought metals. C. P. Development Company, Limited, 97, Lea Bridge Road, Leyton, London, E.10.

Forthcoming Events

JUNE 22-27.

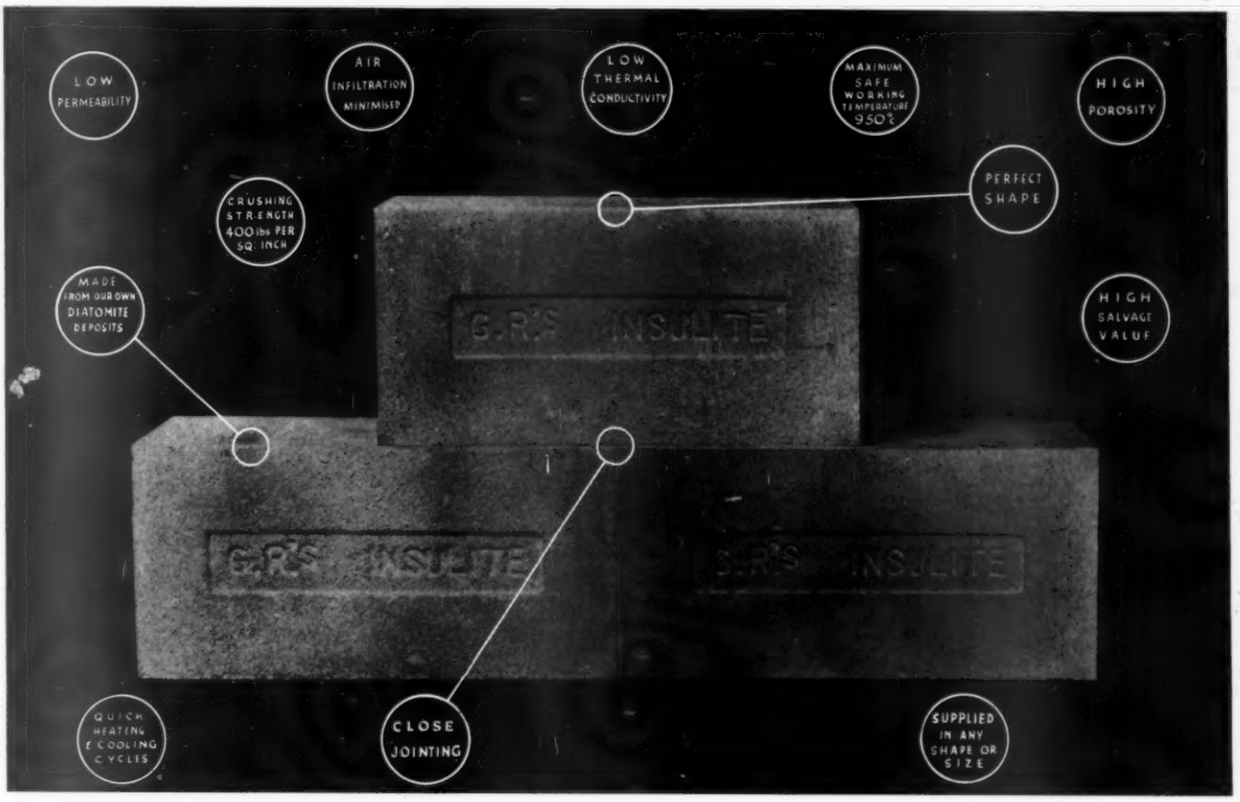
Chemical Engineering Congress, World Power Conference, at Central Hall, Westminster.

JULY 1.

Manchester Association of Engineers:—Works Visits to W. G. Holmes & Company, Limited, and Broadhead & Graves, Limited, of Huddersfield, at 2.15 p.m.

JULY 6-10.

Society of Chemical Industry:—Annual Meeting in Liverpool.



Save 80% of waste heat and reduce fuel costs by 20% with INSULITE BRICKS

By efficiently insulating the foundations and walls of Open Hearth furnaces and Regenerator Chambers, Mould and Core Drying Stoves, Blast Furnace Plant (including Cowper Stoves), Blast Pipes, Annealing and Heat-Treatment Furnaces and Enamelling and General Furnaces —whether heated by solid fuel, gas, oil, or electricity—with Insulite bricks it will be found that there is a saving of 80% of waste heat, fuel costs are reduced by as much as 20%, and production costs are accordingly reduced to a minimum. These bricks also reduce the heat capacity of furnace and stove structures, thereby diminishing the time required to reach top temperature. Although Insulite bricks owe their peculiar properties to their cellular structure it must be remembered *that these cells are closed* and are thus impervious to gases . . . . the serious effects of air infiltration are therefore minimised by the insulating layer. Insulite bricks have extremely high crushing strength of 400 lbs. per sq. inch. Specimen bricks have been removed from behind the lining of plants working at 1,500°C.—these bricks are still perfectly efficient after over 8 years' service.

As each type of furnace has its own peculiarity please write for further particulars to the sole manufacturers of Insulite bricks—our Technical Staff will be pleased to assist without obligation.

GENERAL REFRACTORIES Ltd.,

Genefax House, Sheffield.

Telephone: Sheffield 31113 (6 lines). Telegrams: "Genefax, Sheffield."

London Office:
Russell House,
Adelphi, W.C.2.
Telephone: Temple Bar 7361.
Telegrams:
"Genefax, Rand-London."

Scottish Office:
156, St. Vincent St.,
Glasgow.
Telephone: 5250.
Telegrams:
"Genefax, Glasgow."

South Wales Office:
11, Wind St.,
Swansea.
Telephone: 3680.
Telegrams:
"Genefax, Swansea."

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

Raw Material Markets

Consumers continue to press the makers for deliveries, and a substantial tonnage is changing hands. New business is of rather less volume. Users are endeavouring to accumulate stocks of pig-iron before prices are advanced at the end of this month. Hematite is being well taken up, and makers will shortly bring into operation a loyalty rebate scheme under which prices will be raised by 5s. per ton, a rebate of a similar amount being granted to consumers who enter into the scheme.

Pig-Iron

MIDDLESBROUGH.—Conditions on the Cleveland pig-iron market remain unchanged. Stocks are almost negligible, but makers have been able to dispatch sufficient iron to the consumers to enable them to maintain continuous working. However, deliveries are seriously behind schedule, with little prospect of any relief for several months. For some time the difficulty of obtaining coke supplies has been against the expansion of output, and the forthcoming change in this position is likely to allow producers to increase the pig-iron production. The official minimum prices are purely nominal, and are based on No. 3 quality at 70s. for delivery in Middlesbrough and Falkirk, 72s. on the North-East Coast, and 73s. delivered Clydeside. Buyers are quite willing to pay for any available supplies at quotations in excess of the foregoing figures.

Deliveries of hematite iron are on a good scale, but they are only sufficient to allow works to keep in operation without interruption, and do not make up for previous deficiencies. Most producers have sold the bulk of their output over the third quarter of the year. Values are based on No. 1 grade at 80s. 6d. for delivery to Northumberland, Durham and North Yorkshire.

LANCASHIRE.—Users of Derbyshire and other Midland qualities of foundry iron are taking heavy deliveries in their efforts to secure as large a tonnage as possible before the increased quotations are brought into operation after the end of this month. Any new transactions are only accepted at the new values, which are on the basis of 83s. per ton for Staffordshire and Derbyshire grades of No. 3 iron, delivered in the Lancashire price zone, and 81s. 6d. for Northants No. 3. For delivery equal to Manchester, Scottish foundry iron is quoted at around 90s. per ton, with West Coast hematite at 88s. 6d., and East Coast material at 88s.

MIDLANDS.—June deliveries of pig-iron have been exceedingly heavy and there is every prospect of their being higher than the large total in the previous month. Local ironfounders have well-filled order-books and the demand for common foundry iron is on a good scale. Prices are to be advanced by 5s. per ton on July 1 and, meantime, Northants No. 3 is quoted at 72s. 6d. and Derbyshire, Lincolnshire and North Staffordshire No. 3 at 75s. per ton, delivered Birmingham and Black Country stations. A small sliding-scale rebate is granted to large consumers. Supplies of forge pig-iron are scarce and the furnaces are being hard pressed for deliveries. The price of the latter grade of iron is 5s. per ton below that of No. 3 foundry if required for puddling, but only 3s. less for the foundries. Hematite remains in active demand and supplies are scarce. Prices are unchanged, the controlled quotations delivered to the Birmingham and Black Country area being £4 12s. for West Coast mixed numbers, £4 11s. for East Coast No. 3, and £4 10s. 6d. for Welsh mixed numbers, 1s. 6d. per ton extra being charged for delivery into works in 10-ton lots. Special irons are well taken up by the general engineering and jobbing foundries. Current prices, which are not controlled and are likely to be raised next month, are 92s. 6d. to 100s. for low-phosphorus iron, including Scottish at about 95s.; medium-phosphorus, 80s. to 87s. 6d.; refined irons, £6 10s. to £7 15s., according to analysis, delivered this area.

SCOTLAND.—Firm conditions continue to rule in the Scottish pig-iron market. The official minimum price of No. 3 foundry remains at 79s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. The shortage of Cleveland foundry iron is still a handicap to the light-castings founders, who are well employed. No. 3 Cleveland iron is quoted at 70s. f.o.t. Falkirk and 73s. f.o.t. Glasgow, but no iron is available and thus these figures are purely nominal. Hematite and basic irons are being well taken up by the steelworks and basic has been sold for delivery in the latter half of the year at 75s. per ton, less 5s. rebate, delivered steelworks. Hematite remains at 80s. 6d., delivered steelworks.

Coke

The demand for furnace coke has shown a slight decline recently, but the foundry-coke market still presents a firm appearance. New contracts have been fixed up and most consumers have covered their requirements up to the end of the year. For delivery in Birmingham and district best Durham coke is offered at from 41s. 6d. to 43s., and Welsh from 39s. up to 50s., according to tonnage and quality.

Steel

There is no sign of any decrease in the activity ruling in practically every department of the steel trade. The volume of business offering is in excess of the capacity of the works, and there is an increasing tendency among the manufacturers to concentrate upon working off some of the heavy tonnages they have in hand, states the official report of the London Iron and Steel Exchange. The producers of semi-finished steel are still in arrears with deliveries, although the works are being operated at capacity. The output is passing immediately into consumption; but most consumers are better situated with regard to supplies than was the case a few weeks ago. The demand for finished steel in both the light and heavy departments has become more active; but new business is restricted, as most of the manufacturers are only in a position to accept orders for extended delivery. Inquiry on export account has improved; but the amount materialising into business has been disappointing.

Scrap

Rather quiet conditions have developed on the Cleveland market and, following large importations of scrap from abroad, consumers are well supplied. This is particularly the case where heavy steel is concerned, which is quoted at 57s. 6d. per ton. Machinery metal remains at 65s., while heavy cast iron is at 62s. 6d. The Midland market has also developed an easy appearance, owing to the importation of foreign supplies. Heavy unsheared wrought iron is quiet at 67s. 6d. to 70s. Heavy machinery metal in handy sizes is at 70s., good heavy scrap at 65s., and clean light at 52s. 6d. to 55s. Short, heavy steel, suitable for foundry purposes, is quoted at 70s. per ton, delivered works. The general condition of the Yorkshire market is satisfactory, but buying is not so heavy as in recent weeks. Heavy basic steel receives a good number of inquiries at 55s. to 56s., but some makers will not sell under 57s. 6d., while light basic steel is active at 45s. Mixed wrought iron and steel for basic furnaces is at 54s. 6d. Steelworks heavy cast iron is at 57s. 6d., while foundry cast iron is quoted at 62s. 6d. On the Scottish market there has been a decrease in the number of deliveries and little new business has been transacted. Heavy steel remains at 57s. 6d., while heavy basic, or heavy iron and steel mixed, is 5s. less. Heavy machinery cast-iron scrap in pieces not exceeding 1 cwt. is about 70s., while ordinary cast-iron scrap, to the same specification, is 67s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—There has been little change in the position of this market during the past week. The weekly report issued by Brandeis, Goldschmidt & Company, Limited, states that "the difficult position on the Continent does not appear to have affected the consumption to any appreciable extent, and good sales have been made for forward delivery. As a result, it is expected that further considerable tonnages will be taken from warehouses in this country, and the recent slight increase in Metal Exchange stocks is likely to be only temporary. An improvement in the copper price seems inevitable in the long run, but the immediate outlook depends partly upon the domestic situation in the United States."

Daily market prices :—

Cash.—Thursday, £36 5s. to £36 6s. 3d.; Friday, £36 8s. 9d. to £36 10s.; Monday, £36 10s. to £36 11s. 3d.; Tuesday, £36 11s. 3d. to £36 13s. 9d.; Wednesday, £36 11s. 3d. to £36 13s. 9d.

Three Months.—Thursday, £36 11s. 3d. to £36 12s. 6d.; Friday, £36 13s. 9d. to £36 15s.; Monday, £36 16s. 3d. to £36 18s. 9d.; Tuesday, £36 17s. 6d. to £36 18s. 9d.; Wednesday, £36 17s. 6d. to £36 18s. 9d.

Tin.—Prices have again declined, and the market has been dull. Moderate buying has been transacted in this country, while on the Continent quiet conditions have prevailed. In the United States trading has been quite active, and a fair tonnage has changed hands. A meeting of the International Tin Committee will be held in Paris to-day (Thursday).

Metal Exchange quotations were as follow :—

Cash.—Thursday, £178 5s. to £178 10s.; Friday, £180 to £180 5s.; Monday, £182 10s. to £183; Tuesday, £184 15s. to £185; Wednesday, £185 10s. to £185 15s.

Three Months.—Thursday, £177 to £177 5s.; Friday, £178 10s. to £178 12s. 6d.; Monday, £180 5s. to £180 10s.; Tuesday, £181 5s. to £181 10s.; Wednesday, £182 to £182 10s.

Spelter.—Although some fairly substantial tonnages have changed hands recently the tone of this market remains weak. On the Continent several of the big Belgian zinc-consuming works have closed owing to the labour unrest, and trading has naturally declined. There is little authentic news concerning the revival of the Zinc Cartel. It is believed that late autumn would be the earliest time that any real progress could be reported, and even that is considered unlikely in many quarters. According to the Metallgesellschaft the world's smelter output of zinc in April amounted to 120,093 metric tons, as compared with 121,546 tons in the previous month.

Official quotations were as follow :—

Ordinary.—Thursday, £13 6s. 3d.; Friday, £13 13s. 9d.; Monday, £13 15s.; Tuesday, £13 17s. 6d.; Wednesday, £13 18s. 9d.

Lead.—This market has presented quite a steady appearance. Demand in this country has been well maintained, and the undertone is reported to be sound. In the United States consumption is on a good scale. The American Bureau of Metal Statistics gives the average monthly consumption of lead in the first four months of this year as 28,889 metric tons, compared with 27,692 tons in the corresponding period of 1935.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 1s. 3d.; Friday, £15 3s. 9d.; Monday, £15 1s. 3d.; Tuesday, £15 2s. 6d.; Wednesday, £15 5s.

Publication Received

Electrical Progress. The use of foolscap envelopes no doubt accounts for the strange shape of a little booklet, which was sent out to the shareholders of the General Electric Company, Limited, with the notice convening the annual meeting of the company. Its object, well conceived and executed, is to remind shareholders that they may be able to do some little propaganda work by familiarising themselves with the main lines of manufactures undertaken by the company.

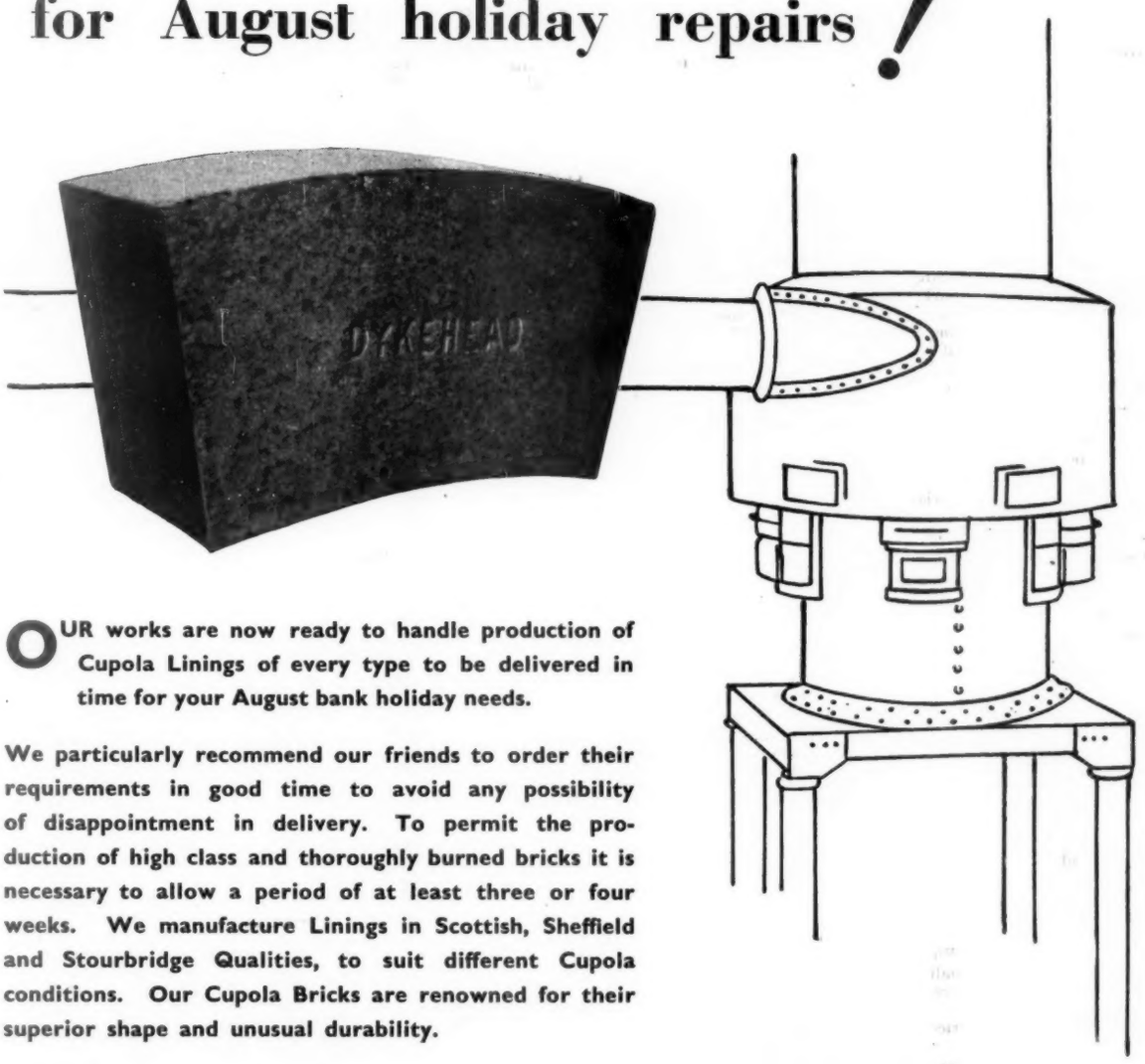
Vanadiam from Basic Open-Hearth Slags

Vanadium can be extracted from basic open-hearth slags by acid treatment, according to M. W. SAPADINSKI in "Katschestwennaja Stal." The slag is heated to 950 deg. C. and then treated at ordinary temperatures with a mixture of sulphuric and hydrochloric acids, when vanadic acid goes into solution on heating. Tests were made on a slag containing 8 per cent. V_2O_5, 18.62 per cent. Cr_2O_3, 12.45 per cent. MnO, 8.82 per cent. CaO, 9.46 per cent. MgO, 16 per cent. SiO_2, 0.3 per cent. P_2O_5 and 26 per cent. Fe, and a product obtained containing 99 per cent. V_2O_5.

NOW is the time to order

CUPOLA LININGS

for August holiday repairs!



OUR works are now ready to handle production of Cupola Linings of every type to be delivered in time for your August bank holiday needs.

We particularly recommend our friends to order their requirements in good time to avoid any possibility of disappointment in delivery. To permit the production of high class and thoroughly burned bricks it is necessary to allow a period of at least three or four weeks. We manufacture Linings in Scottish, Sheffield and Stourbridge Qualities, to suit different Cupola conditions. Our Cupola Bricks are renowned for their superior shape and unusual durability.

Please write, phone or call for further particulars.

GENERAL REFRACTORIES LIMITED

Telephone: *Sheffield* 31113 (*six lines*).. *Telegrams:* "*Genefax, Sheffield.*"

Genefax House, Sheffield

London Office:
Russell House,
Adelphi, W.C.2.
Telephone: Temple Bar 7361.
Telegrams:
"Genefax, Rand-London."

Scottish Office:
156, St. Vincent St.,
Glasgow.
Telephone: 5250.
Telegrams:
"Genefax, Glasgow."

South Wales Office:
11, Wind St.,
Swansea.
Telephone: 3680.
Telegrams:
"Genefax, Swansea."

RAW MATERIALS—PRICE LIST

(Wednesday, June 24, 1936)

COPPER

	£ s. d.
Standard cash	36 11 3
Three months	36 17 6
Electrolytic	40 15 0
Tough	39 0 0
Best selected	39 10 0
Sheets	68 0 0
India	49 17 6
Wire bars	41 2 6
Ingot bars	41 0 0
H.C. wire rods	44 12 6
Off. av. cash, May	36 14 6¾
Do., 3 mths., May	37 0 2½
Do., Sttlmnt., May	36 14 6¾
Do., Electro, May	41 0 8½
Do., B.S., May	40 9 2
Do., wire bars, May	41 4 7½
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	6½d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8¾d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7½d.
Rolled metal	7⅞d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	185 10 0
Three months	182 0 0
English	185 5 0
Bars	186 10 0
Straits	187 5 0
Australian (nom.)	—
Eastern	185 5 0
Banca	187 5 0
Off. av. cash, May	202 12 1½
Do., 3 mths., May	197 4 4½
Do., Sttlmt., May	202 12 4½

SPELTER

	£ s. d.
Ordinary	13 18 9
Remelted	13 5 0
Hard	11 5 0
Electro 99.9	16 0 0
English	14 15 0
India	12 10 0
Zinc dust	19 10 0
Zinc ashes	4 5 0
Off. aver., May	14 13 1½
Aver. spot, May	14 10 8½

LEAD

Soft foreign ppt.	15 5 0
Empire	15 17 6
English	17 5 0
Off. average, May	15 11 3¾
Average spot, May	15 10 7½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	23 10 0 to 24 0 0
Do., V.M. ex-whse.	23 10 0 to 24 0 0
Rods	26 0 0

ANTIMONY

English	66 10 0 to 67 10 0
Chinese, ex-whse.	53 0 0
Crude, c.i.f.	25 0 0

QUICKSILVER

Quicksilver	11 12 6 to 12 2 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum— 70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium— 20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 0 0 to £22 0 0
Ferro-tungsten— 80/85%	3/- lb.
Tungsten metal powder— 98/99%	3/3 lb.
Ferro-chrome— 2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome— Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium— 96/98%	2/5 lb.
Ferro-manganese (net)— 76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	(nom.) £10 5 0
Metallic manganese— 94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 3 0	to 3 4 0
Mixed iron and steel	2 19 0	to 3 0 0
Heavy cast iron	2 17 6	to 2 19 0
Good machinery	3 1 6	to 3 4 0
Cleveland—		
Heavy steel	2 17 6	
Steel turnings	2 0 0	
Heavy cast iron	3 2 6	
Heavy machinery	3 5 0	
Midlands—		
Light cast-iron scrap	2 12 6	to 2 15 0
Heavy wrought iron	3 7 6	to 3 10 0
Steel turnings	2 2 0	to 2 2 6
Scotland—		
Heavy steel	2 17 6	
Ordinary cast iron	3 7 0	
Engineers' turnings	2 2 6	
Cast-iron borings	1 17 6	
Wrot-iron piling	3 10 0	
Heavy machinery	3 10 0	

London—Merchants' buying prices, delivered yard.

Copper (clean)	29 0 0
Brass	19 0 0
Lead (less usual draft)	13 10 0
Tea lead	9 0 0
Zinc	8 10 0
New aluminium cuttings	74 0 0
Braziery copper	26 0 0
Gunmetal	27 0 0
Hollow pewter	130 0 0
Shaped black pewter	108 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	72/6
,, No. 3	70/-
,, No. 4	69/-
Forge No. 4	69/-
Hematite No. 1	80/6
Hematite M/Nos.	80/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	80/6
,, d/d Birm.	92/-
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	72/-
,, No. 3 fdry.	75/-
Northants forge	69/6
,, fdry. No. 3	72/6
,, fdry. No. 1	75/6
Derbyshire forge	72/-
,, fdry. No. 3	75/-
,, fdry No. 1	78/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	73/-
,, ,, Falkirk	70/-
Scottish hem. M/Nos. d/d	80/6
Sheffield (d/d district)—	
Derby forge	69/6
,, fdry. No. 3	72/6
Lincs forge	69/6
,, fdry. No. 3	72/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	78/-
Staffs fdry. No. 3	78/-
Northants fdry. No. 3	76/6
Cleveland fdry. No. 3	78/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	90/-
Clyde, No. 3	90/-
Monkland, No. 3	90/-
Summerlee, No. 3	90/-
Eglinton, No. 3	90/-
Gartsherrie, No. 3	90/-
Shotts, No. 3	90/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 2 6
Nut and bolt iron	8 10 0	to 9 0 0
Hoops		11 0 0 and up.
Marked bars (Staffs) f.o.t.		12 10 0
Gas strip		11 0 0 and up.
Bolts and nuts, ¾ in. × 4 in.		15 15 0 and up.
Steel—		
Plates, ship, etc.	9 7 6	to 9 10 0
Boiler plts.	9 17 6	to 10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5½ in.		10 0 0
Rounds under 3 in. to ⅜ in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		11 10 0
Galv. cor. shts. (,,)		13 10 0
Galv. flat shts. (,,)		14 0 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6 and up.
Billets, hard	7 2 6	to 7 7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	11½d.
Tubes	14d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round— to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	28.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.85
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 31/-
,, furnace	24/- to 26/-
Durham foundry	25/- to 26/-
,, furnace	22/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	26/9 to 27/-
,,	18¾×14 ,,	19/6
C.W.	20×14 ,,	15/6 to 15/9
,,	28×20 ,,	33/9 to 34/-
,,	20×10 ,,	22/6 to 22/9
,,	18¾×14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
June 18 ..	36	5	0	No	change
„ 19 ..	36	8	9	inc.	3/9
„ 22 ..	36	10	0	„	1/3
„ 23 ..	36	11	3	„	1/3
„ 24 ..	36	11	3	No	change

Electrolytic Copper

	£	s.	d.		
June 18 ..	40	2	6	dec.	2/6
„ 19 ..	40	5	0	inc.	2/6
„ 22 ..	40	10	0	„	5/-
„ 23 ..	40	15	0	„	5/-
„ 24 ..	40	15	0	No	change

Standard Tin (cash)

	£	s.	d.		
June 18 ..	178	5	0	dec.	45/-
„ 19 ..	180	0	0	inc.	35/-
„ 22 ..	182	10	0	„	50/-
„ 23 ..	184	15	0	„	45/-
„ 24 ..	185	10	0	„	15/-

Tin (English ingots)

	£	s.	d.		
June 18 ..	178	10	0	dec.	40/-
„ 19 ..	180	0	0	inc.	30/-
„ 22 ..	182	15	0	„	55/-
„ 23 ..	184	15	0	„	40/-
„ 24 ..	185	5	0	„	10/-

Spelter (ordinary)

	£	s.	d.		
June 18 ..	13	6	3	dec.	2/6
„ 19 ..	13	13	9	inc.	7/6
„ 22 ..	13	15	0	„	1/3
„ 23 ..	13	17	6	„	2/6
„ 24 ..	13	18	9	„	1/3

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
June 18 ..	15	8	9	dec.	2/6
„ 19 ..	15	16	3	inc.	7/6
„ 22 ..	15	17	6	„	1/3
„ 23 ..	16	0	0	„	2/6
„ 24 ..	16	0	0	No	change

Lead (soft foreign, prompt)

	£	s.	d.		
June 18 ..	15	1	3	No	change
„ 19 ..	15	3	9	inc.	2/6
„ 22 ..	15	1	3	dec.	2/6
„ 23 ..	15	2	6	inc.	1/3
„ 24 ..	15	5	0	„	2/6

Lead (English)

	£	s.	d.		
June 18 ..	17	0	0	No	change
„ 19 ..	17	0	0	„	„
„ 22 ..	17	0	0	„	„
„ 23 ..	17	0	0	„	„
„ 24 ..	17	5	0	inc.	5/-

Imports and Exports of Pig-Iron and Steel Castings, etc., in May, and the Five Months 1936, compared with May, and the Five Months 1935.

	May.		Five Months.		May.		Five Months.	
	1935.	1936.	1935.	1936.	1935.	1936.	1935.	1936.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	5,389	12,244	32,623	34,719	17,575	38,030	96,828	108,162
„ Foreign Countries	1,008	8,795	5,549	18,278	5,897	35,918	32,621	84,318
Total	6,397	21,039	38,172	52,997	23,472	73,948	129,449	192,480
Castings and forgings	250	673	1,333	3,608	6,186	26,499	34,477	121,445
Cast pipes and fittings	33	99	298	544	1,765	4,083	13,027	20,055
Stoves and grates, etc.	94	79	448	302	8,871	8,501	41,181	34,243
Baths	647	561	2,715	2,810	17,558	13,916	74,193	70,946
Hollow-ware, all kinds	206	258	1,024	1,347	17,348	14,998	70,175	77,761
Exports.								
Pig-iron, forge and foundry	9,737	5,980	39,439	22,695	36,059	25,552	138,456	87,543
„ acid	6,926	1,941	23,255	14,279	23,070	6,984	75,136	49,389
„ basic	27	3	231	108	123	12	727	557
Total	16,690	7,924	62,925	37,082	59,252	32,548	214,319	137,489
Castings and forgings	272	379	1,694	1,944	11,389	13,152	64,593	69,137
Cast pipes and fittings, up to 6 in. diameter	4,327	5,537	22,030	23,437	50,637	65,325	246,034	263,011
„ „ „ over 6 in.	3,251	3,022	16,075	17,986	25,169	26,952	124,254	147,615
Stoves, grates, etc.	890	770	3,458	4,225	39,446	40,261	169,172	214,542
Sanitary cisterns	242	249	1,265	1,271	7,218	7,827	35,769	40,042
Bedsteads, including tubes therefor	429	385	1,875	2,067	13,078	14,611	67,327	77,179
Cast hollow-ware	304	529	1,618	2,255	11,730	16,330	62,396	78,190

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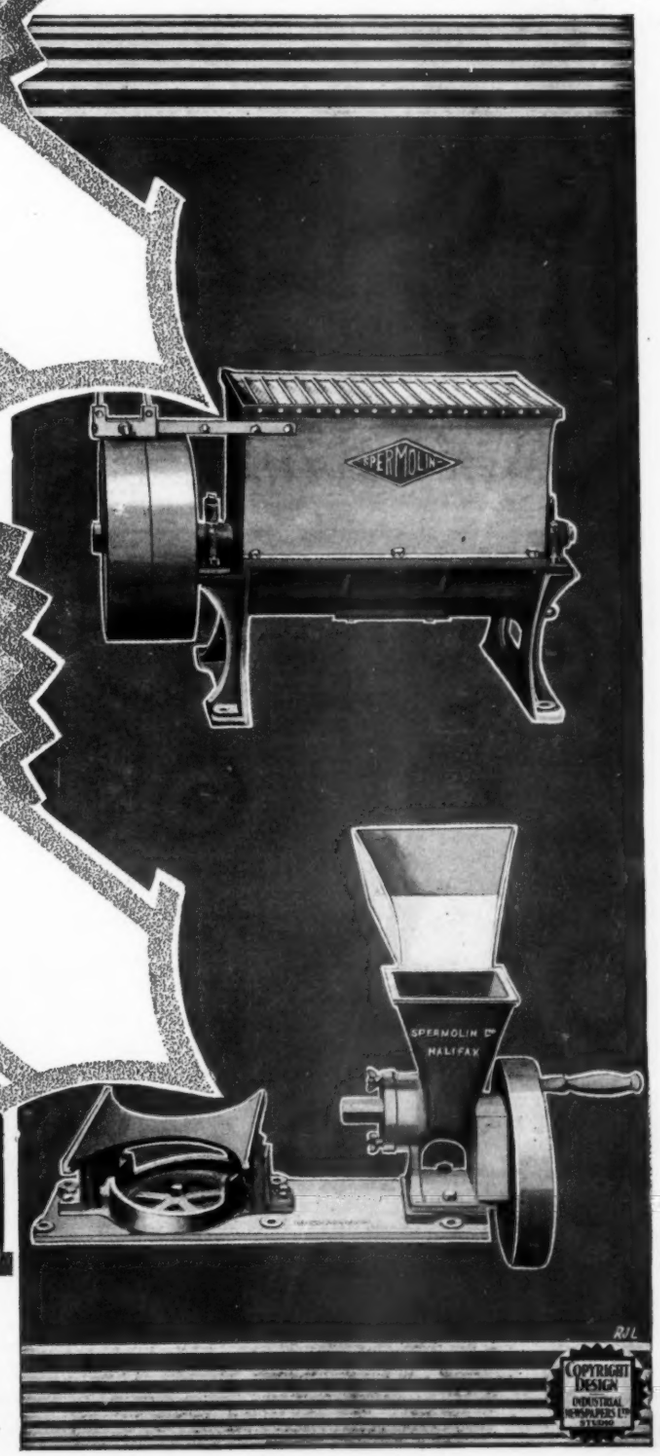

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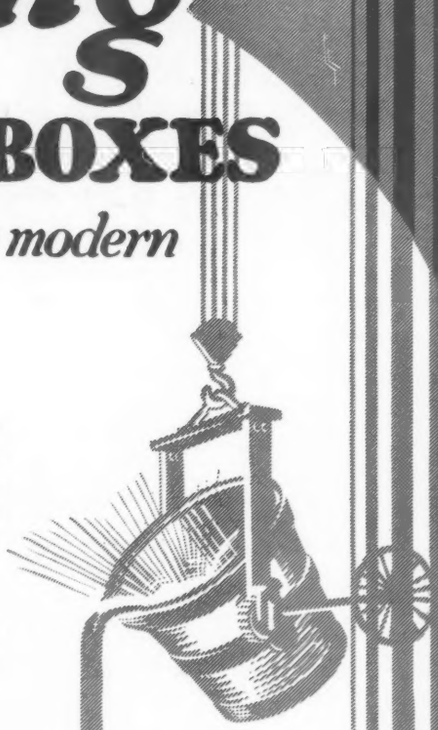

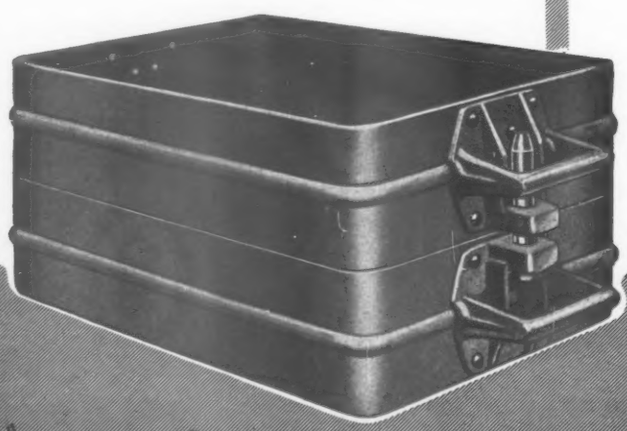

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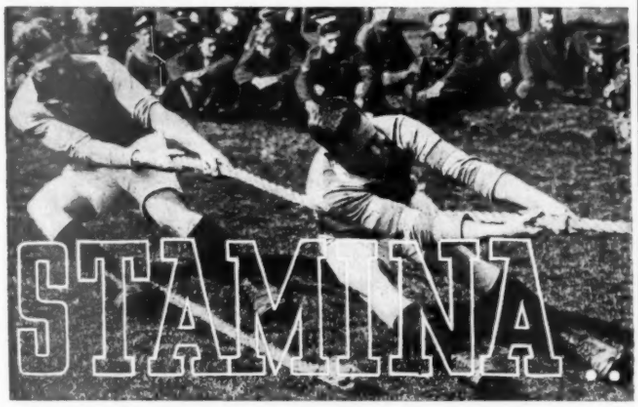

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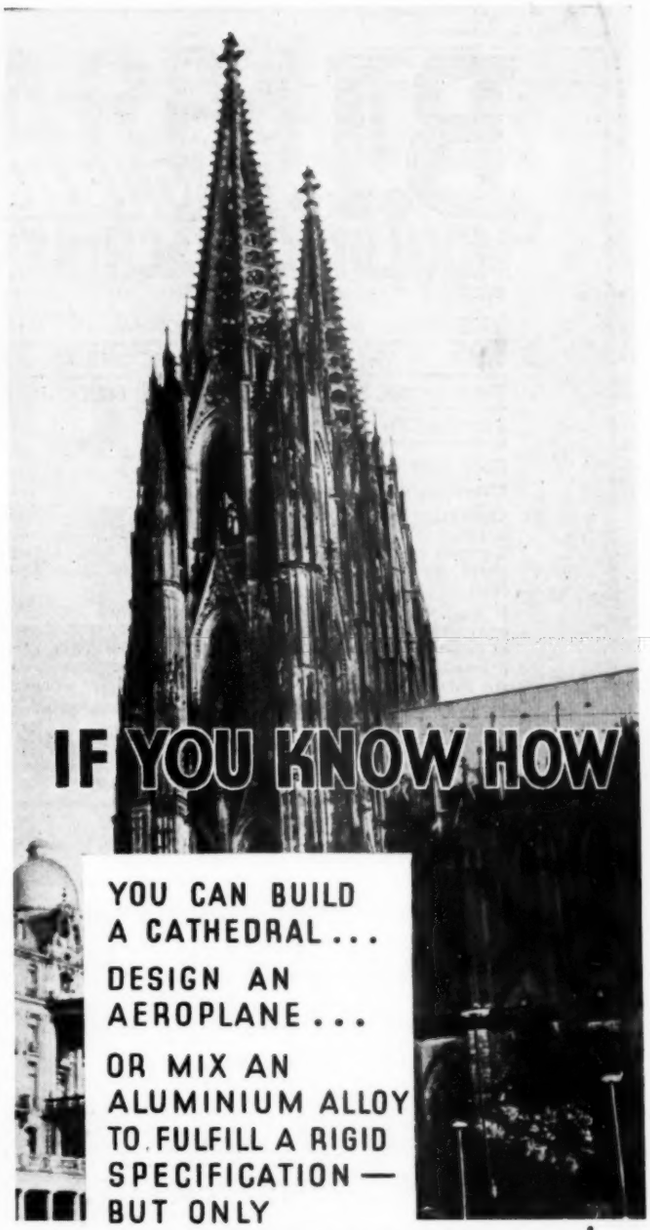
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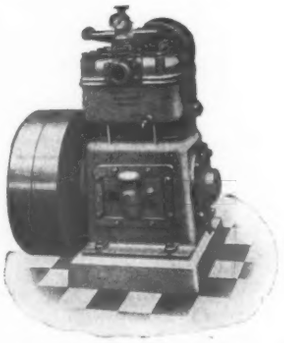

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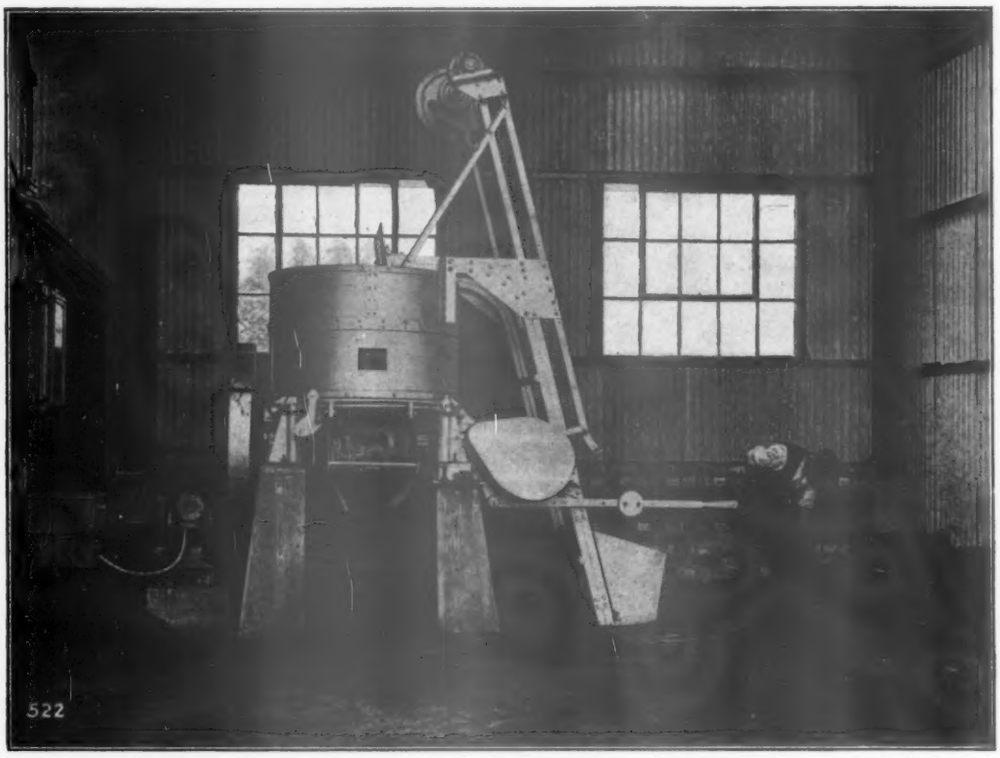

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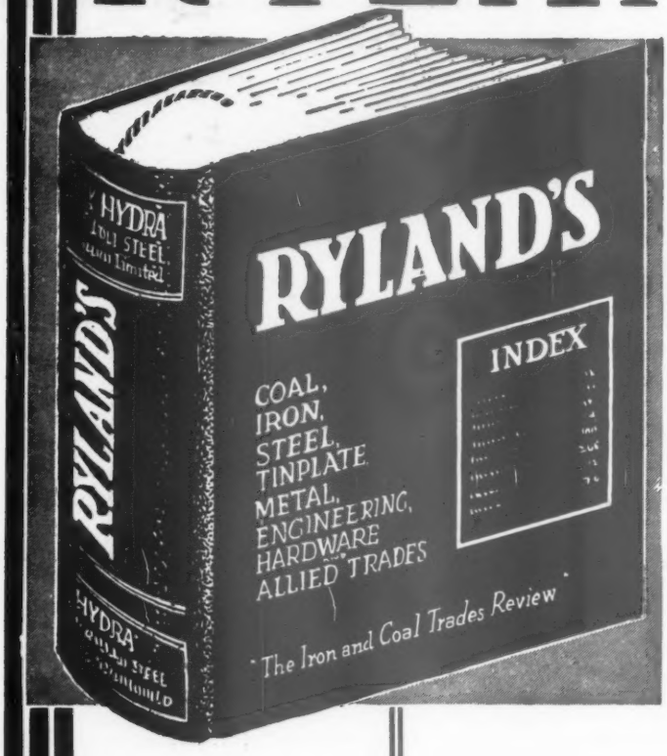

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,, (combined)	0·30	0·40	0·04	0·08	0·12	0·24	0·30	0·50
Silicon	2·0 to 3·0	2·0 to 3·0	4·0 to 5·0	2·5 to 4·0	2·5 to 4·0	2·0 to 4·0	2·0 to 3·5	2·0 to 3·0
Sulphur	0·03	0·04	0·01	0·01	0·02	0·03	0·04	0·06 to 0·08
Phosphorus	0·75	0·75	1·4 to 1·5	1·4 to 1·5	1·4 to 1·5	1·4 to 1·5	1·4 to 1·5	1·4 to 1·5
Manganese	1·3 to 1·5	1·2 to 1·4	0·8 to 1·4	0·8 to 1·4	0·8 to 1·4	0·8 to 1·4	0·8 to 1·4	0·8 to 1·2

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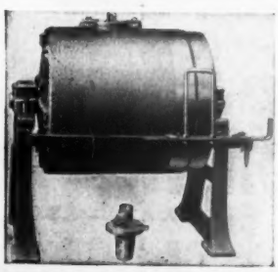

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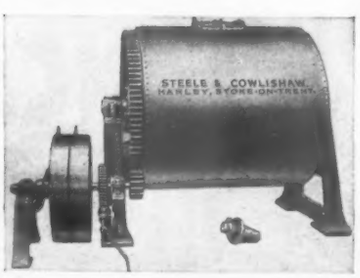

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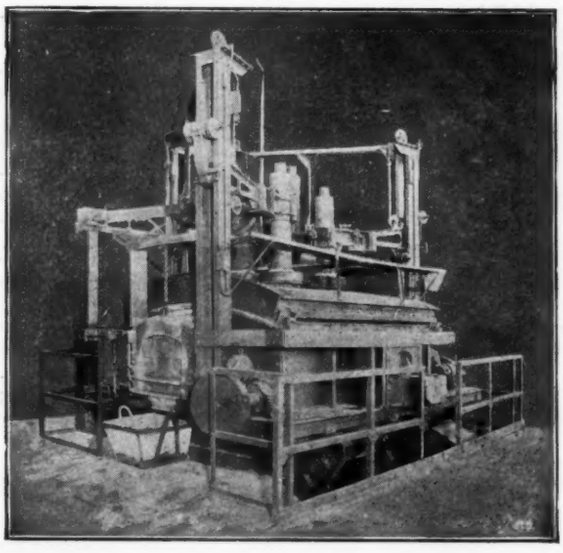

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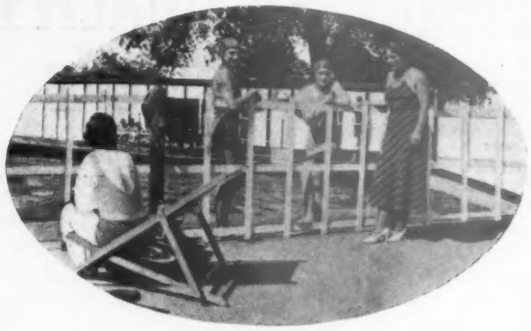

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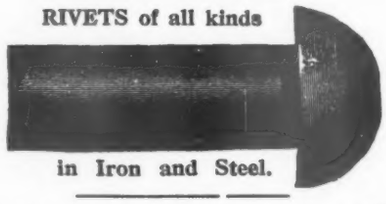

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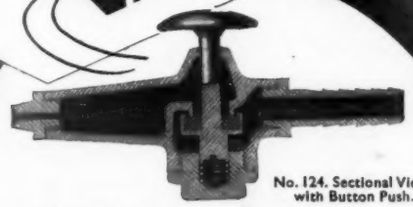

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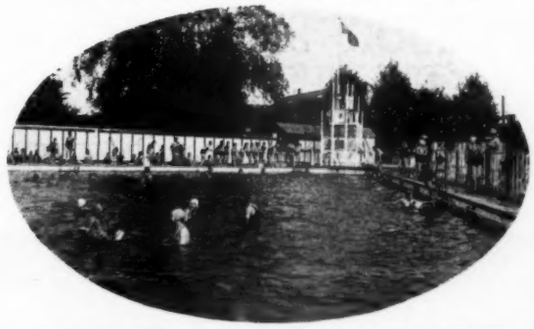

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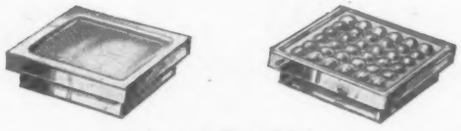

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